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CONTENTS OF VOLUME IX.

Number 33.

		PAGE
The Value of Cæcostomy in the Treatment of Malignant Disease of the Colon	*Sir Harold Stiles*	1
Eponyms :—		
Colles's Fracture	*Sir D'Arcy Power*	4
Fractures of the Carpal Scaphoid	*Alan H. Todd*	7
The Palliative Treatment of Aneurysm by 'Wiring' with Colt's Apparatus	*Sir D'Arcy Power*	27
Observations on Fifty Cases of Hour-glass Stomach subjected to Operation	*W. Thelwall Thomas*	37
A Case of Hour-glass Stomach	*G. A. Ewart*	42
Intussusception : A Monograph based on 400 Cases	*W. S. Perrin and E. C. Lindsay*	46
Suppurating Teratomatous Cyst in the Splenic Region ..	*W. G. Spencer*	72
Tumours of the Salivary Glands, with their After-history ..	*R. Kennon*	76
Visits to Surgical Clinics at Home and Abroad :—		
Plastic Surgery at the Queen's Hospital, Sidcup		87
The Prognosis of Carcinoma Mammæ : A Review of 169 Cases	*G. Percival Mills*	91
A Case of Unilateral Polycystic Disease of the Kidney in a Child, age Two Years	*Andrew Fullerton*	99
Congenital Occlusion of the Ileum	*John Morley*	103
The Kondoléon Operation for Elephantiasis	*Arnold K. Henry*	111
Injuries of the Diaphragm, with Special Reference to Abdominothoracic Wounds	*C. W. Gordon Bryan*	117
Skin-grafting in the Buccal Cavity	*T. P. Kilner and T. Jackson*	148
Short Notes of Rare or Obscure Cases	*Various Writers*	155
Reviews and Notices of Books		163

Number 34.

Reconstruction of the Common Bile-duct	*A. J. Walton*	169
Study of some Methods of Bone-grafting	*Maud Forrester-Brown*	179
Eponyms :—		
Baker's Cysts, and Baker's Tracheotomy Tubes ..	*Sir D'Arcy Power*	200
Chronic Duodenal Ileus	*D. P. D. Wilkie*	204
Testicular Symptoms in Appendicitis	*Zachary Cope*	215

410818

PAGE

FRACTURE OF THE HUMERUS IN AN INDIVIDUAL WITH OBSCURE BONY LESIONS *E. E. Hughes* 217

NOTE ON A SERIES OF 100 OPERATIONS FOR GALL-STONES IN PRIVATE PATIENTS: WITH SPECIAL REFERENCE TO RECURRENCE .. .. .. *Sir Gilbert Barling* 221

CYSTIC DISEASE OF THE FIRST RIB CAUSING LOWER-ARM (KLUMPKE) TYPE OF PARALYSIS *W. C. B. Meyer* 224

TUBERCULOSIS OF THE FLAT BONES OF THE SKULL .. *Valentine St. John* 228

A FURTHER CONTRIBUTION TO THE STUDY OF CYSTS AND PAPILLOMATA OF THE BREAST *Sir George Lenthal Cheatle* 235

RECONSTRUCTION OF ANKYLOSED KNEE-JOINTS .. *Sir W. I. de Courcy Wheeler* 242

RECONSTRUCTION OF THE SHOULDER .. .. *Sir W. I. de Courcy Wheeler* 247

BRONCHOBILIARY FISTULA .. .. *Arthur H. Burgess* 253

TRACTION FRACTURE OF THE LESSER TROCHANTER OF THE FEMUR .. *H. Poston* 256

THE OPERATIVE TREATMENT OF CLOSED FRACTURES OF THE LONG BONES BY METAL BANDS, WITH A DESCRIPTION OF A NEW INSTRUMENT *E. Gerald Stanley and Jean Gatellier* 259

VISITS TO SURGICAL CLINICS AT HOME AND ABROAD:—

The Clinic of Dr. Hugh Hamilton Young: the Buchanan Brady Institute of the Johns Hopkins Hospital, Baltimore, Maryland, U.S.A. 272

The Clinic of Sir Harold Stiles, Edinburgh 281

DEFICIENCY OF THE MESENTERY OVER THE LOWER ILEUM .. *George E. Armstrong* 287

CLEFT PALATE: THE ADVANTAGES OF A TWO-STAGE OPERATION *Thomas H. Kellock* 290

INSTRUCTIVE MISTAKES 293

SHORT NOTES OF RARE OR OBSCURE CASES .. .. *Various Writers* 295

REVIEWS AND NOTICES OF BOOKS 314

NUMBER 35.

THE TUBE SKIN-FLAP IN PLASTIC SURGERY .. *H. P. Pickerill and J. Renfrew White* 321

EPONYMS:—

Brodie's Tumour, and Brodie's Abscess .. .. *Sir D'Arcy Power* 334

A STUDY OF THE SURGICAL PATHOLOGY OF HYPERNEPHROMATA: WITH SPECIAL REFERENCE TO THEIR ORIGIN AND SYMPTOMATOLOGY .. .. *Henry W. S. Wright* 336

PSEUDO-COXALGIA: A CLINICAL AND RADIOGRAPHIC STUDY.. .. *Harry Platt* 366

NON-UNION OF FRACTURES .. .. *H. J. Waring and E. T. C. Milligan* 408

CARCINOMA OF THE JEJUNUM AND ILEUM .. .. .. *Raymond Johnson* 422

VISITS TO SURGICAL CLINICS AT HOME AND ABROAD:—

The Clinic of Sir Berkeley Moynihan 431

LIGATION OF THE INNOMINATE ARTERY FOR INNOMINATE ANEURYSM *Sir Charles Ballance* 438

PAGE

Radical Cure of Inguinal Hernia in Children, with Special Reference to the Embryonic Rests found associated with the Sacs .. *Alex. MacLennan* 445

Restoration of the Nose by Transplantation of Skin from the Forehead in the Year 1881 .. .. *T. Pridgin Teale* 449

The Gastric Crises of Tabes Dorsalis and their Surgical Treatment *R. C. Shawe* 450

Short Notes on Rare of Obscure Cases .. .. *Various Writers* 458

Reviews and Notices of Books 468

Number 36.

Eponyms :—

William Hey, of Leeds .. .. *Sir D'Arcy Power* 473

Pneumococcal Peritonitis .. .. .. *J. E. McCartney and John Fraser* 479

A Case of Epilepsy of Twenty-two Years' Standing due to a Calcified Endothelioma or Perithelioma in the left lateral Ventricle: Removal and Recovery .. .. *Sir John Lynn-Thomas* 490

The Use of Pituitrin in Inoperable Cancer .. .. .. *J. H. Norgate* 495

Inguinal Herniæ: Their Varieties, Mode of Origin, and Classification *R. Hamilton Russell* 502

Hydronephrosis .. .. *Charles A. Pannett* 509

Multicentric Origin of a Rodent Ulcer .. .. *Sir G. Lenthal Cheatle* 529

Selenium in the Treatment of Malignant Disease *A. S. Gillett and C. P. G. Wakeley* 532

Some Observations on Bone-grafting, with Special Reference to Bridge-Grafts *C. Max Page and G. Perkins* 540

Excision of the Os Calcis for Tuberculous Osteitis: A Late End-result *C. P. G. Wakeley* 553

Recurrent Anterior Dislocation of Lower End of Ulna Complicated by Ununited Fracture of the Styloid Process of the Ulna *A. Philp Mitchell* 555

Multiple Papillomata of the Small Intestine causing Recurrent Intussusception in an Adult .. .. *Zachary Cope* 558

Visits to Surgical Clinics at Home and Abroad :—

The Clinic of Professor Raffaele Bastianelli, Rome 560

Short Notes of Rare or Obscure Cases .. .. .. *Various Writers* 565

Reviews and Notices of Books 576

GENERAL INDEX TO VOLUME IX.

THE
BRITISH JOURNAL OF SURGERY

THE VALUE OF CÆCOSTOMY IN THE TREATMENT OF MALIGNANT DISEASE OF THE COLON.*

By Sir HAROLD STILES, Edinburgh.

Malignant disease of the colon is one which all of us encounter as part of the routine of our general surgical work. In spite of the fact that the subject has been much discussed, it seems to me that surgeons are by no means unanimous as to the best method of dealing with it. In proof of this I need only mention the recent paper in the *Annals of Surgery* for February, 1920, by Mr. Dowd, of New York, who is a strong advocate of the Mikulicz operation; and to a paper in the *Journal of the American Medical Association* for July 31, 1920, by Mr. Bevan, of Chicago, who, like myself, is equally convinced of the value of cæcostomy.

Although the disease runs a chronic course, and the sign-posts which point to its presence are generally obvious enough, it is surprising, as well as somewhat deplorable, to find that so many cases do not reach the surgeon until the symptoms have culminated in complete obstruction. The symptoms ought to be sufficiently appreciated by the medical attendant to rouse his suspicion at any rate, and all he has to do is to call in the aid of a good radiographer who can not only settle the diagnosis but, what is equally important from the surgeon's point of view, can also demonstrate the position of the tumour. And here I would like to emphasize the importance of giving a bismuth enema as well as a bismuth meal; indeed, of the two, I am inclined to think the latter often gives us the more information.

From the surgical point of view we have to consider, first, the treatment when the disease has been diagnosed before complete obstruction has set in, and, secondly, the treatment when this complication has arisen. In order the better to develop my thesis, let me deal with the latter first.

Most of us are old enough to remember the day when it was the custom to open the abdomen and, having searched for and found the obstruction, to proceed at once to remove it and to re-establish the continuity of the canal. It is unnecessary to dwell upon the tragic results which followed such a procedure; we are all only too painfully conscious of them and would gladly blot them from our memories. We are now all agreed that the right thing to do is to be contented with relieving the obstruction in the first instance, and, when possible, to remove the disease at a subsequent operation. Suppose that our patient with complete obstruction is enfeebled from age, or is in other respects a bad subject for operation, I think we are equally agreed that it is our duty to relieve the obstruction in the simplest possible way and with a minimum of risk to the patient.

The history, along with the absence of a tumour in the rectum, enables us to say almost with certainty that the obstruction is situated somewhere in the large intestine above that organ; in which case all that is necessary is to make a small incision in the right iliac region, to bring out a small diverticulum of the cæcum, and to suture its base very carefully to the peritoneum and the deeper muscles. If the relief of the obstruction has become urgent, the bowel may be drained forthwith by the introduction of a small Paul's tube. I say a *small* tube advisedly, because the contents of the cæcum are more or less fluid, and will therefore drain through a small tube; moreover, by using a small

* Part of an address introductory to the Annual Meeting of the Association of Surgeons of Great Britain and Ireland.

one the resulting fistula will generally close spontaneously after the obstruction has been removed. If necessary, the operation can easily be done under local anæsthesia.

In doing this simple operation, experience has taught me that on no account should the whole cæcum be pulled out of the wound. If this is done there is a grave risk that as soon as the bowel is deprived of the support of the abdominal wall it will at once become so distended and ballooned that its peritoneum is almost certain to split, and there is even a danger of rupture of all the coats.

The next point we have to consider is whether, in the presence of complete obstruction, the hand should be introduced into the abdomen in search of the exact situation of the tumour before proceeding to do the cæcostomy. In my opinion this is unnecessary, as the site of obstruction can be ascertained by radiography after the patient has been tided over the obstruction. If, however, the obstruction be of the *subacute* variety, and the patient's general condition is otherwise satisfactory, the surgeon may feel justified in introducing his hand into the abdomen before proceeding with the cæcostomy. In the event of his deciding to do so, he may either enlarge the iliac wound sufficiently for the purpose, or may make a separate medial (or paramedial) incision. On the whole I am in favour of the latter: firstly, because it gives better access to the whole abdomen; and secondly, because the wound can easily be protected from contamination from the cæcostomy opening, whereas we have no certain means of preventing infection of the wound in the iliac region.

It is wonderful how rapidly the patient recovers from the effects of the obstruction after the cæcum has been opened; by getting rid of the stasis in the small bowel the patient's general health improves so much that the major operation may be done ten days or so after the cæcostomy.

It is unnecessary for me to enter into any details regarding the enterectomy, but what I would like to emphasize is how much I have been impressed by the smooth and uneventful convalescence which even old people have made who have undergone a secondary enterectomy after a primary cæcostomy for complete obstruction; indeed, in many cases, on account of the absence of all flatulence, they have complained less than patients often do who have undergone a simple appendectomy during a quiescent period. The cæcostomy opening has acted as a safeguard against gas-pressure.

But this is by no means the only advantage of the preliminary cæcostomy. By preventing distention from flatulence, it not only prevents pain and discomfort, it also gives rest to the bowel; it takes the strain off the intestinal sutures, and almost eliminates the risk of a localized abscess and fæcal fistula developing about a week or ten days after operation, a complication due to a slight leakage or necrosis at the suture line.

Now let us consider the methods which may be adopted in the absence of obstruction.

In the simple cases, the surgeon may decide to complete the operation in one stage by resecting a portion of the bowel and restoring continuity either by an end-to-end or a lateral anastomosis. The only complication which is likely to interrupt the patient's convalescence seriously is the one I have just referred to. It is with the object of avoiding this complication that most surgeons, I think, prefer to do a lateral anastomosis rather than a direct end-to-end union. Now experience has shown that this complication almost never happens after resection of the proximal third of the large bowel, the explanation no doubt being that the contents of this part of the intestine are more or less fluid and therefore readily pass through the seat of anastomosis. In the more distal portion of the large bowel, on the other hand, the fæces are more solid, and when the lumen has been markedly strictured by the tumour it often happens that the castor oil which has been given preparatory to the operation has failed to empty the bowel, and that too much strain is put on the sutured bowel, partly by the solid fæces and, perhaps to a still greater extent, by the distention caused by the accumulated flatus.

It is to get over this difficulty that many surgeons, even in the absence of obstruction, prefer to employ the two-stage operation which is associated with the names of Paul and Mikuliez. Although this may be a safer method, it is certainly a more trying ordeal for the patient. Moreover, the closure of the bowel after the spur has been got rid of is

not always such a simple matter as it sounds, and not infrequently a second operation is called for before it is finally effected. The result is that many weeks may elapse before the patient is out of the surgeon's hands.

In dealing with malignant disease between the hepatic flexure and the pelvirectal junction, the question we have to consider, therefore, is whether it is possible to find a compromise between the two procedures above referred to—a method, that is to say, which combines the advantages of both without possessing the disadvantages and risks of either.

The experience I have had in dealing with the cases which have been operated on when the obstruction has become complete has convinced me that there is such a method, and that the risks which attend the one-stage operation may be largely, if not entirely, eliminated by opening the cæcum. I have entirely given up the Mikulicz operation. For the past ten years it has been my invariable practice, in the absence of obstruction, to do a primary resection followed by an end-to-end anastomosis; and then, as the final step of the operation, to make a small incision over the cæcum and, by means of a carefully applied continuous suture, to stitch the circumference of an area of the anterior wall of the cæcum about the size of a two-shilling piece to the parietal peritoneum and the two deeper muscles. The cæcum is opened twenty-four or forty-eight hours later. A tube about the diameter of a lead pencil is introduced to keep the opening patent. The opening, by providing for the escape of flatus, acts as an efficient safety-valve in preventing all strain on the intestinal sutures. As already mentioned, the patient has almost always a painless and uneventful convalescence; moreover, there is no hurry or anxiety about the giving of an aperient to get the bowels to move. Quite frequently there is a movement by the rectum without the help of an aperient; if one should be necessary it need not be given until the end of the first week, by which time the healing of the bowel will have become secure.

The opening in the cæcum need only be about three-quarters of an inch in length, and as it is not intended to be permanent its edges should not be sutured to the skin. In the majority of cases the fistula will have closed spontaneously either when, or shortly after, it is time for the patient to leave the hospital, which he usually does in about three weeks from the date of operation. From the patient's point of view, therefore, this procedure possesses a great advantage over the Mikulicz operation.

To prevent fæcal matter from the cæcostomy opening reaching the main wound, all that is necessary is to cover over the gauze dressing with a sheet of batiste and fix to the skin (with Michel's clips) the edge which is directed towards the cæcostomy opening.

In my opinion there are three advantages which may be claimed for combining a small cæcostomy opening with a primary resection. They are :—

1. It allows of an end-to-end union with safety.

2. This, again, makes it easier to remove a greater extent of bowel, mesentery, and glands than if it were intended to re-establish continuity by a lateral anastomosis.

3. It is sometimes possible to effect an end-to-end union in cases in which a lateral anastomosis would be impracticable; for example, when the tumour is situated rather near the pelvirectal junction.

I have become so convinced of the great value of cæcostomy in the treatment of malignant disease of the large intestine that I have seriously considered the question as to whether it is advisable to do it as a preliminary to a resection at a later date, even in the absence of obstruction, just as we do a sigmoidotomy preliminary to removal of the rectum. It is true that in the latter case we divert the whole of the fæces from the pelvic wound, whereas by the cæcostomy we only divert a part of them; it is enough, however, to provide a safety-valve. I will at any rate go so far as to advise a preliminary cæcostomy in patients who, while not suffering from complete obstruction, are to be regarded as bad operative risks, because after the cæcostomy they may pick up sufficiently to warrant the risk of the major operation.

Lastly, let me take the opportunity to mention the value also of cæcostomy in the treatment of megalocolon, of volvulus of the sigmoid, and of certain cases of diverticulitis. Here, again, the cæcostomy may be done either as a preliminary to the major operation, or as a part of it, according as the merits of the case demand.

EPONYMS.[*]

By Sir D'ARCY POWER, K.B.E., London.

It is proposed to give in the following series of articles the *ipsissima verba* of those surgeons whose names are associated with the diseases or injuries to which they first called attention. Many of these descriptions are so short that they can be reproduced at length; others will be abbreviated; but all are so clear that they have gained a world-wide acceptance. Most medical students and many of their teachers are posed when they are asked: Why is the injury called 'Colles's fracture'? Where is 'Brodie's abscess' described? Why are 'Baker's cysts' so called? Was it the same surgeon to whom 'Pott's fracture', 'Pott's puffy swelling', and 'Pott's disease of the spine' are assigned? Where and when did Paget write about 'osteitis deformans' and his 'disease of the breast'? To those who know where to look for them the original papers are not hard to find, but as few have the inclination or the leisure to discover them this series of short articles may prove both instructive and interesting.

I. COLLES'S FRACTURE.

The Edinburgh Medical and Surgical Journal, 1814, Vol. X, page 182, contains an article "'On the Fracture of the Carpal Extremity of the Radius', by A. Colles, M.D., one of the Professors of Anatomy and Surgery in the Royal College of Surgeons in Ireland", of which the following is a complete transcript:—

"The injury to which I wish to direct the attention of surgeons, has not, as far as I know, been described by any author; indeed, the form of the carpal extremity of the radius would rather incline us to question its being liable to fracture. The absence of crepitus and of the other common symptoms of fracture, together with the swelling which instantly arises in this, as in other injuries of the wrist, render the difficulty of ascertaining the real nature of the case very considerable.

"This fracture takes place at about an inch and a half above the carpal extremity of the radius, and exhibits the following appearances.

"The posterior surface of the limb presents a considerable deformity; for a depression is seen in the forearm, about an inch and a half above the end of this bone, while a considerable swelling occupies the wrist and metacarpus. Indeed, the carpus and base of metacarpus appear to be thrown backward so much as on first view to excite a suspicion that the carpus has been dislocated forward. On viewing the anterior surface of the limb, we observe a considerable fulness, as if caused by the flexor tendons being thrown forwards. This fulness extends upwards to about one-third of the length of the forearm, and terminates below at the upper edge of the annular ligament of the wrist. The extremity of the ulna is seen projecting towards the palm and inner edge of the limb; the degree, however, in which this projection takes place, is different in different instances.

"If the surgeon proceed to investigate the nature of this injury, he will find that the end of the ulna admits of being readily moved backwards and forwards.

"On the posterior surface, he will discover by the touch that the swelling on the wrist, and metacarpus, is not caused entirely by an effusion among the softer parts; he will perceive that the ends of the metacarpal, and second row of carpal bones, form no small

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[*] **Eponym** [ad. Gr. ἐπώνυμος]. One who gives, or is supposed to give, his name to a people, place, or institution. Also in Lat. form, *eponymus*. (*N.E.D., sub voce.*)

part of it. This, strengthening the suspicion which the first view of the case had excited, leads him to examine, in a more particular manner, the anterior part of the joint ; but the want of that solid resistance, which a dislocation of the carpus forward must occassion (*sic*), forces him to abandon this notion, and leaves him in a state of perplexing uncertainty as to the real nature of the injury. He will, therefore, endeavour to gain some information by examining the bones of the fore-arm. The facility with which, (as was before noticed,) the ulna can be moved backward and forward, does not furnish him with any useful hint. When he moves his fingers along the anterior surface of the radius, he finds it more full and prominent than is natural ; a similar examination of the posterior surface of this bone, induces him to think that a depression is felt about an inch and a half above its carpal extremity. He now expects to find satisfactory proofs of a fracture of the radius at this spot. For this purpose, he attempts to move the broken pieces of bone in opposite directions ; but, although the patient is by this examination subjected to considerable pain, yet, neither crepitus nor a yielding of the bone at the seat of fracture, nor any other positive evidence of the existence of such an injury, is thereby obtained. The patient complains of severe pain as often as an attempt is made to give the limb the motions of pronation and supination.

" If the surgeon lock his hand in that of the patient's, and make extension, even with a moderate force, he restores the limb to its natural form, but the distortion of the limb instantly returns on the extension being removed. Should the facility with which a moderate extension restores the limb to its form, induce the practitioner to treat this as a case of sprain, he will find, after a lapse of time sufficient for the removal of similar swellings, the deformity undiminished. Or, should he mistake the case for a dislocation of the wrist, and attempt to retain the parts *in situ* by tight bandages and splints, the pain caused by the pressure on the back of the wrist will force him to unbind them in a few hours ; and, if they be applied more loosely, he will find, at the expiration of a few weeks, that the deformity still exists in its fullest extent, and that it is now no longer to be removed by making extension of the limb. By such mistakes the patient is doomed to endure for many months considerable lameness and stiffness of the limb, accompanied by severe pains on attempting to bend the hand and fingers. One consolation only remains, that the limb will at some remote period again enjoy perfect freedom in all its motions and be completely exempt from pain ; the deformity, however, will remain undiminished through life.

" The unfavourable result of some of the first cases of this description which came under my care, forced me to investigate with peculiar anxiety the nature of the injury. But while the absence of crepitus and of the other usual symptoms of fracture rendered the diagnosis extremely difficult ; a recollection of the superior strength and thickness of this part of the radius, joined to the mobility of its articulation with the carpus and ulna, rather inclined me to question the possibility of a fracture taking place at this part of the bone. At last, after many unsuccessful trials, I hit upon the following simple method of examination, by which I was enabled to ascertain, that the symptoms above enumerated actually arose from a fracture, seated about an inch and a half above the carpal extremity of the radius.

" Let the surgeon apply the fingers of one hand to the seat of the suspected fracture, and, locking the other hand in that of the patient, make a moderate extension, until he observes the limb restored to its natural form. As soon as this is effected, let him move the patient's hand backward and forward ; and he will, at every such attempt, be sensible of a yielding of the fractured ends of the bone, and this to such a degree as must remove all doubt from his mind.

" The nature of this injury once ascertained, it will be a very easy matter to explain the different phenomena attendant on it, and to point out a method of treatment which will prove completely successful. The hard swelling which appears on the back of the hand, is caused by the carpal surface of the radius being directed slightly backwards instead of looking directly downwards. The carpus and metacarpus, retaining their connections with this bone, must follow it in its derangements, and cause the convexity above

alluded to. This change of direction in the articulating surface of the radius is caused by the tendons of the extensor muscles of the thumb, which pass along the posterior surface of the radius in sheaths firmly connected with the inferior extremity of this bone. The broken extremity of the radius being thus drawn backwards, causes the ulna to appear prominent toward the palmar surface, while it is possibly thrown more towards the inner or ulnar side of the limb, by the upper end of the fragment of the radius pressing against it in that direction. The separation of these two bones from each other is facilitated by a previous rupture of their capsular ligament; an event which may readily be occasioned by the violence of the injury. An effusion into the sheaths of the flexor tendons will account for that swelling which occupies the limb anteriorly.

"It is obvious that, in the treatment of this fracture, our attention should be principally directed to guard against the carpal end of the radius being drawn backwards. For this purpose, while assistants hold the limb in a middle state between pronation and supination, let a thick and firm compress be applied transversely on the anterior surface of the limb, at the seat of fracture, taking care that it shall not press on the ulna; let this be bound on firmly with a roller, and then let a tin splint, formed to the shape of the arm, be applied to both its anterior and posterior surfaces. In cases where the end of the ulna has appeared much displaced, I have laid a very narrow wooden splint along the naked side of this bone. This latter splint, I now think, should be used in every instance, as, by pressing the extremity of the ulna against the side of the radius, it will tend to oppose the displacement of the fractured end of this bone. It is scarcely necessary to observe, that the two principal splints should be much more narrow at the wrist than those in general use, and should also extend to the roots of the fingers, spreading out so as to give a firm support to the hand. The cases treated on this plan have all recovered without the smallest defect or deformity of the limb, in the ordinary time for the cure of fractures.

"I cannot conclude these observations without remarking, that were my opinion to be drawn from these cases only which have occurred to me, I should consider this as by far the most common injury to which the wrist or carpal extremities of the radius and ulna are exposed. During the last three years I have not met with a single instance of Dessault's dislocation of the inferior end of the radius, while I have had opportunities of seeing a vast number of the fracture of the lower end of this bone.

"*Stephens Green, February* 21, 1814."

Thus, with 1528 words and at the age of 41, Colles secured for himself a permanent name in surgery. It may be observed that his account is strictly clinical, for he had no opportunity of making a pathological examination of the injury.

In 1837 Colles dedicated his *Practical Observations on the Venereal Disease* to Sir Astley Cooper. In an interesting chapter on "Syphilis in Infants", he says (p. 285): "It is a curious fact that I have never witnessed nor ever heard of an instance in which a child deriving the infection of syphilis from its parents has caused an ulceration in the breast of its mother." This statement, which was found to be true, afterwards passed current as 'Colles's law', though it is sometimes called Baumès' law; as Baumès noted the same fact in 1840, three years after Colles had enunciated it. It was not until 1865 that Guiseppe Profeta pointed out that "a healthy child born of a syphilitic mother can be suckled by her or by a syphilitic wet nurse with impunity", which is Profeta's law.

FRACTURES OF THE CARPAL SCAPHOID.

By ALAN H. TODD, London.

The great majority of the cases of fracture of the carpal scaphoid that present themselves in the wards or the out-patient department of Guy's Hospital are examples of old fracture, and the reason for attending is invariably the same, viz., that the wrist is not as good as it was, or as it should be, and that it interferes materially with the wage-earning capacity, either because it hurts, or is weak, or for both reasons. On inquiring into the history, it generally transpires that the case was not diagnosed as one of fracture at the time of the initial injury; usually it was regarded and treated as one of 'sprain'. In other words, it is only when serious sequelæ have arisen and failed to disappear even after some months or years of symptomatic treatment, that a correct diagnosis is generally made; and the acute fracture, as such, is very often missed. In the special Fracture Out-patient Department (where all ambulatory fractures are treated), such cases are comparatively rare; only 9 have been found there, in a consecutive series of 3000 cases of one sort and another. In this particular department, all cases of injury of the wrist, of whatsoever kind, are examined with the *x* rays as a routine procedure, and a plate is always taken; the wrist is examined anteroposteriorly and laterally, and sometimes obliquely as well, so that it is improbable that many cases of fracture of the scaphoid are overlooked. Moreover, since the writer's attention was first directed particularly to this class of case, the radiograms of all the Colles's fractures and other injuries in the neighbourhood of the wrist have been re-examined, and no example of fracture of the scaphoid has been discovered amongst them.

In the general surgical clinics, cases of recent fracture of the carpal scaphoid are practically never seen: it appears, therefore, to be justifiable to conclude that: (1) A number of recent cases of this fracture are overlooked, and either do not come to hospital at all, or else are to be sought for in the minor-casualty departments, being treated for 'sprain' or the like; (2) When all cases of injury in the region of the wrist are *x*-rayed as a routine, with a good technique, fracture of the carpal scaphoid can always be detected. In other words, given a due appreciation of the likelihood of such an injury being present, and given also an opportunity for radiographic examination, there is no excuse for cases being wrongly diagnosed.

Without in any way condoning carelessness in the diagnosis of fractures in general, one must admit that there are cases in which failure to detect that a fracture is present does not materially damage the patient, in so far as his ultimate functional result is concerned. In many cases of incomplete fracture, for example (such as were invariably overlooked until the advent of *x* rays), a layman would probably be quite willing to use his limb as long as he regarded it as being merely sprained, and probably he would get a very good result in consequence. If, however, he knew that it had been fractured, he would regard the injury as being much more serious; even if it were only a fracture in the most technical sense of the phrase, he would be inclined to avoid using his limb, to anticipate pain and disability, and so on, and the ultimate result might very well be impaired in consequence. The public does not discriminate, as a rule, between various types and degrees of fracture; for them, a fracture is a fracture, and a very serious thing too. This pessimistic belief is unfortunately not altogether unjustified, for after all it is the conclusion that the public has arrived at in the light of bitter experience; they judge by results, by what they themselves have seen and experienced, and no one could deny that the results of fracture treatment in the past have often left much to be desired.

The factor of suggestion and autosuggestion is also a large one in determining the functional result after fracture. It is not many years since the medical profession generally was accustomed to encase the limb in rigid splints for a very long time after a fracture, and to enjoin perfect rest and various irksome restrictions ; the whole atmosphere of the patient seemed almost to be designed so as to magnify the gravity of the injury. Even when the splints were taken off, there was a long period of after-treatment to be faced ; wasted muscles to be exercised, stiff joints to be moved, and adhesions to be painfully broken down. The ultimate result was not always good, and patients were told (and learned for themselves) that they must expect pain if they wanted to get a good result, or, perhaps, that they must expect always to have some physical disability. It is hardly to be wondered at, then, if the public look upon fractures rather pessimistically at the present time ; their view-point to-day is the outcome of the way in which they were treated, and the things they were told, yesterday ; tradition changes slowly. We have taught them to regard a fracture as being a very serious thing, usually associated with pain and disablement ; therefore they expect them, and even if they are not always present they imagine them. That is to say, traumatic hysteria is very common after fractures ; but it is quite preventable, partly by our doing much better work in the future than we did in the past, and partly by our educating the public up to quite a different conception of fractures.

But in the case of fractures of the carpal scaphoid there is no question of hysteria, or of any other form of suggestion or autosuggestion ; if a case is not properly diagnosed and treated, there will be serious disability, almost to a certainty, and probably it will be permanent. Medical writers are not given to recording their failures ; yet the literature of fractured scaphoid teems with accounts of operations performed in the hope of mitigating the disability that has ensued on a 'missed' fracture. And these operations have not been very successful on the whole ; for though many authors have claimed good results in individual cases, or in very small series of cases, yet a large number of different procedures have been described—a sure proof that no one method has shown itself to be really good. The majority of surgeons are very pessimistic concerning the prognosis in cases of old fracture of the scaphoid, with or without operation, and it would be difficult to find anyone who would guarantee to make a man's wrist normal again by operation, after such a fracture.

In all the cases of old fracture that the writer has seen, the complaint has been the same, viz., that the condition of the wrist was such that it interfered materially with the man's wage-earning capacity. Either it was painful, or it was weak, or it was liable to catch or to give way just as the patient was performing some muscular action ; sometimes swelling was complained of, but generally it has been mechanical weakness or unreliability. All the Guy's cases have occurred in men of early adult age ; most of them have been mechanics. In this small series, as in all published cases, the majority of the fractures have occurred in the right hand. In every case, a definite history of the causal injury could be obtained without difficulty ; the man could say just when it happened, and what he was doing at the time ; he was always quite clear as to the precise moment at which the damage was done, and there was no question of his merely presuming that an injury must have taken place, when he came to think the matter over in the light of subsequent experience. On the other hand, it was not always possible to ascertain the exact mechanism of the fracture, the patient having very often forgotten the precise position of the hand and wrist at the time. The most common account is that the man fell on to the outstretched palm, the wrist, of course, being hyperextended. Occasionally, the hyperextension is the result of a motor-engine back-firing, and not of a fall. At any rate, in those cases in which the fracture has resulted from overextension of the wrist, there has always been a considerable amount of force exerted ; fracture of the carpal scaphoid is never the result of a mild injury. The violence necessary to break the bone is such that it is very unlikely to be forgotten ; this is a point of much importance in connection with the much-debated question of bipartite scaphoid versus fracture (*vide infra*). In yet other cases a different kind of mechanism altogether seems to have come

into play; in certain instances, for example, the bone has apparently been broken with the wrist hyperflexed, and certain writers regard this as the normal mechanism of fracture; in the present series, however, hyperextension together with the exercise of considerable violence appears to have been the usual mechanism.

The first step, then, towards the diagnosis of fracture of the carpal scaphoid consists in eliciting the history of the causal injury, which is very definite and characteristic.

The next point is to make out what the results of this injury were. These also are very definite, and appear to the writer to be both striking and characteristic. The first sign, as a rule, is swelling; it appears almost at once, and is most marked in the region known as the 'anatomical snuff-box'; it is never great, and it is never very widespread; the tendons which form the boundaries of the snuff-box may be obscured, and the œdema may sometimes spread a little way upwards, tending rather to follow the line of the lower end of the radius; but it never surrounds the whole wrist, and it seldom even extends right across the back of it. Very seldom indeed does it travel down the back of the hand towards the base of the index finger. The folds at the wrist are never obliterated. In short, the swelling takes the form of a rapid, localized œdema on the dorsum of the radial half of the wrist-joint (*Fig.* 1). In true sprain of the wrist (by which should be meant traumatic synovitis of the wrist-joint, and no other condition), the swelling is much greater in amount, and much more diffuse. But the chief point to emphasize in connection with 'sprained wrist' is that it is an excessively rare condition—so rare, in fact, that many surgeons who have great experience of fractures doubt its very existence. As Speese[64] well says, " Sprain of the wrist is a diagnosis which is less and less tenable ". If only this fact were as fully appreciated as it should be, a very large number of fractures of various kinds (not to mention other important injuries, such as dislocations of various carpal bones, especially the semilunar) would be discovered, and much prolongation of disability and depreciation of earning capacity would be avoided in consequence. It is extraordinary that the diagnosis of sprained wrist is so commonly made, when as a matter of fact the injury so rarely occurs. In tenosynovitis, such as sometimes follows a violent wrench of the wrist, there is swelling, but this is usually all about the extensor tendons, and extends right across the back of the wrist, whilst the snuff-box is not particularly swollen. Moreover, the typical soft crepitation that characterizes tenosynovitis is always very easily perceptible when the examiner's fingers are placed flat upon the back of the wrist and the joint is then moved to and fro.

FIG. 1.—The typical œdema of a case of fractured scaphoid.

In the early stages the swelling is ordinary soft œdema; if the case is recognized as one of fracture of the scaphoid, and is skilfully treated, it will probably disappear. But if it is overlooked or neglected, some part of the swelling will almost certainly persist for years afterwards; in any case of 'missed' fracture, it is always possible to detect some fullness in the snuff-box, whilst the tendons defining that space are a little less obvious than they are on the uninjured side. At this late stage the swelling is not purely œdema, of course; some of it is due to actual organic thickening; but a part is still caused by œdema, set up, presumably, by the effect of moving the arthritic joint. At operation it

is usually quite easy to demonstrate these two elements that go to make up the chronic swelling, viz., the œdema and the organized inflammatory material.

Ecchymosis is extremely rare in fractures of the scaphoid, because rupture of the capsule of the wrist-joint is very rare in these cases, whereas in severe contusion of the tissues about the joint ecchymosis is both common and widespread.

So much for what may be seen by a mere inspection of the wrist at rest. We come now to palpation. A careful observer will make his diagnosis practically without having to move the wrist at all; at any rate it need only be moved a very little, and it is never necessary to put the patient to any severe pain in order to ascertain that a fracture of the scaphoid has occurred, no matter whether the case be a recent or a late one. The first point that will be ascertained is that there is acute local tenderness; this is situated just beyond the radial styloid process, in the anatomical snuff-box; it is, in fact, just over the proximal fragment of the scaphoid. Special care should be taken in defining the exact site of the tenderness, for it is an important point in the differential diagnosis; for instance, in fracture of the radial styloid process itself, the tenderness is a little higher up, and more on the outer border of the limb, whilst in Colles's fracture the line of tenderness is again over the exact site of fracture, i.e., some ¾ in. above the lower articular surface of the radius. In fact, as J. B. Murphy[47] puts it, "the first stage of the diagnosis is the appreciation of the fact that the injury is substyloid". The mere fact, however, that a person is tender in the snuff-box, and that such tenderness is limited to the region of the snuff-box, is not enough to warrant a diagnosis of fracture of the scaphoid. In recent cases, of course, there will be the œdema, and the pain and the impairment of function, to make the diagnosis clear; but in old cases there may be a possibility of mistake. Every one is tender, to some extent, in the proximal half of the anatomical snuff-box, because that is just where the dorsal branch of the radial nerve runs, and firm pressure there is capable of injuring it. But it is quite easy to distinguish radial-nerve pain from fractured-scaphoid pain, because the nerve-pain is not nearly so acute as the pain that is associated with fracture (even old fracture), and it becomes less after a few moments during which the pressure is maintained, because pressure-anæsthesia supervenes; in the case of fracture, however, the pain becomes unbearable. Moreover, the nerve-tenderness can be elicited in either wrist by an equal amount of pressure, whereas the fracture-tenderness is presumably unilateral as a rule. In recent cases the tenderness of the fracture is considerable; one author describes it as a 'wincing' tenderness, and this is a very good description, which gives a very accurate and graphic impression of what one sees in such cases.

FIG. 2.—Showing the transmission directly to the scaphoid of the force of a blow applied to head of second metacarpal.

Another valuable method of eliciting the tenderness is by means of the application of force at a distance, i.e., the indirect jarring of the site of fracture. This is the principle involved in Vaughan's knuckle-percussion test. The metacarpophalangeal joints are all flexed to a right angle, or, if possible, the patient is made to clench his fist; he is then told to keep his eyes shut, whilst the surgeon taps the knuckles smartly, one after another, with an ordinary rubber-headed knee-jerk hammer. If fracture of the scaphoid is present, sharp pain will be elicited when the head of the second metacarpal is struck, but not when any of the others is struck; *Fig.* 2 shows quite clearly that the force of a blow upon the end of the second metacarpal would be transmitted directly along the bone to the trapezoid and scaphoid, whereas a blow on any of the others would be dissipated before it could

reach the scaphoid. Incidentally, it may be pointed out that it would be the third metacarpal that would be tender in cases of fracture of the semilunar. This point is sometimes helpful in the differential diagnosis, either before *x*-ray examination or in places where an *x*-ray apparatus is not available. Vaughan's test is very reliable when it is positive, but it is not invariably present; in the first few days after a fracture it can generally be demonstrated without difficulty; but a week or more after the date of injury, some patients will allow the second metacarpal to be quite sensibly jarred without making any complaint.

In the acute stage, the typical swelling, the severe pain that is made worse by every sort of movement, the acute tenderness just over the scaphoid distal to the radial styloid process, and the limitation of movement, especially of dorsiflexion of the wrist, make up a picture that is so absolutely characteristic that it is always possible to diagnose fracture of the scaphoid with perfect confidence; it is incredible that anyone who is conversant with the physical signs of this fracture could ever miss a case. The only possible explanation for the marked preponderance of 'missed' cases over recent cases is that these signs are not familiar to the generality of practitioners. In view of the very grave disability that ensues when a fracture of the scaphoid is overlooked, however, it is clearly of great importance that the attention of the rank and file of our profession should be drawn to this fracture, and to its diagnosis and treatment.

Even in a late case the typical swelling is not always totally absent; some trace of it is often to be observed, in the form of a puffiness in the region of the snuff-box. Tenderness, too, can sometimes be elicited; if the fragments of the scaphoid are completely ununited, or if the bone has united with excess of callus, there may be definite local tenderness on pressure directly over the bone. Any attempt, moreover, to extend the wrist beyond its ordinary range will result in pain.

Limitation of extension of the wrist-joint is present from the first. If perfect gentleness is exercised in the clinical examination, it is usually possible to get a man with a fractured scaphoid to flex his wrist, but by no means can he be induced to extend the joint to more than 45° at the very most; nor should one persist in trying, for the mere fact that extension is markedly limited and painful tells us all that we need to know. In late cases the limitation still persists; even after the lapse of some years any attempt to thrust the wrist forcibly back to the normal extent will cause pain. It seems probable that this pain is mainly a referred pain, whilst the limitation of movement is chiefly caused by muscular spasm, for the pain and limitation are mostly observed in those cases in which there is an actual arthritis present, and the limitation disappears entirely under anæsthesia; if it were due to adhesions, this would not be the case. In other words, even the late rigidity and limitation of movement (extension) are to be regarded as being largely protective mechanisms.

To conclude the clinical examination of the patient, two minor points in the differential diagnosis may be noted: firstly, that the measurements of the two limbs are exactly the same (which would not be the case in a typical Colles's fracture, for example), and, secondly, that there is no muscular wasting at any stage.

It is only since the advent of *x* rays that fractures of the carpal bones have been recognized at all. In fact, there is practically no literature at all upon the subject prior to the year 1900; Hamilton dismisses the subject with the remark that of course the carpus may be involved in severe crushes of the whole limb; whilst other large and authoritative works have nothing to say about the subject at all. Stimson, in 1900, wrote that crepitation was the one cardinal sign, whereas as a matter of fact it never occurs.

Radiography should, of course, be employed as a routine in the examination of every case of injury in the region of the wrist; by this means many obscure cases will be rendered perfectly clear, and a vague and unconvincing diagnosis will be converted into a precise and satisfactory one. Practically every case of so-called 'sprain' of the wrist will be found to be in reality something else, and one may justifiably paraphrase Punch's famous advice, and say, "To those about to diagnose sprained wrist,—Don't". When damaged wrists are *x*-rayed as a routine, fractures of the carpus are not overlooked, for

with a proper technique they are quite easy to detect; it is because these cases are not always radiographed that mistakes occur, and that we meet with so many overlooked fractures. As we observed in our opening paragraph, it is not in the special fracture departments of our hospitals that we meet with the 'missed' cases, but in the minor dressing rooms, casualty departments, and so on.

We have said that fractures of the scaphoid are easy to detect, provided that a proper technique is employed. As a corollary to this, one should hasten to add that without a proper technique it is very easy to overlook a fracture, or to diagnose fracture where none

FIGS. 3 & 4.—False shadow, due to bad centration of *x*-ray tube.

exists. In the first place, the shape of the scaphoid varies somewhat in different persons, according to their age, occupation, and so on. But what is far more important is that very great variations in the apparent shape of the bone may result from variations in the position of the hand, or of the fluorescent tube as compared with the hand, at the time when the radiogram is being taken. *Figs.* 5 and 8 illustrate this point very clearly, whilst *Figs.* 3 and 4 are two instances, picked at random out of a large number of *x*-ray pictures of the carpus, to show how imperfect centration may vitiate the shadow obtained. It is evident from the most cursory examination of these radiograms that the best view of the bone is obtained when the hand is in the position of ulnar deflection, as in *Figs.* 5 and 6; even when the hand is held normally in line with the forearm the scaphoid is very clearly seen, but here the foreshortened view of the tuberosity of the bone begins to be apparent; when the hand is in the position of radial deflection, as in *Fig.* 8, the tuberosity stands out very clearly as a sort of second shadow superimposed upon the normal thickness of the bone. Very often the outline of the tuberosity does not coincide accurately with that of the rest of the bone, and thus there is produced an appearance of a notch on the outer border of the bone; this is very frequently diagnosed by the uninitiated as a fracture, but by carefully scrutinizing the lower articular surface of the bone, i.e., that for the os magnum, it will be seen that there is no evidence of fracture there (*Figs.* 9 and 10). Occasionally the notch-like border of the tuberosity has been described as evidence of a compression-fracture of the edge of the scaphoid produced by impaction upon the styloid process of the radius, but this is simply a misinterpretation of radiographic appearances; such a fracture does not occur.

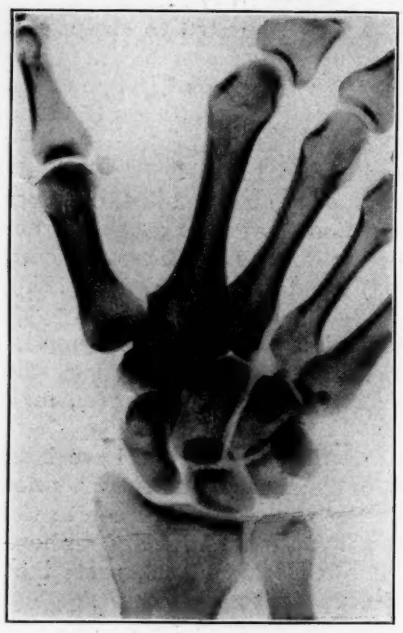


FIG. 5.—Normal carpus in adduction, or ulnar deflection.

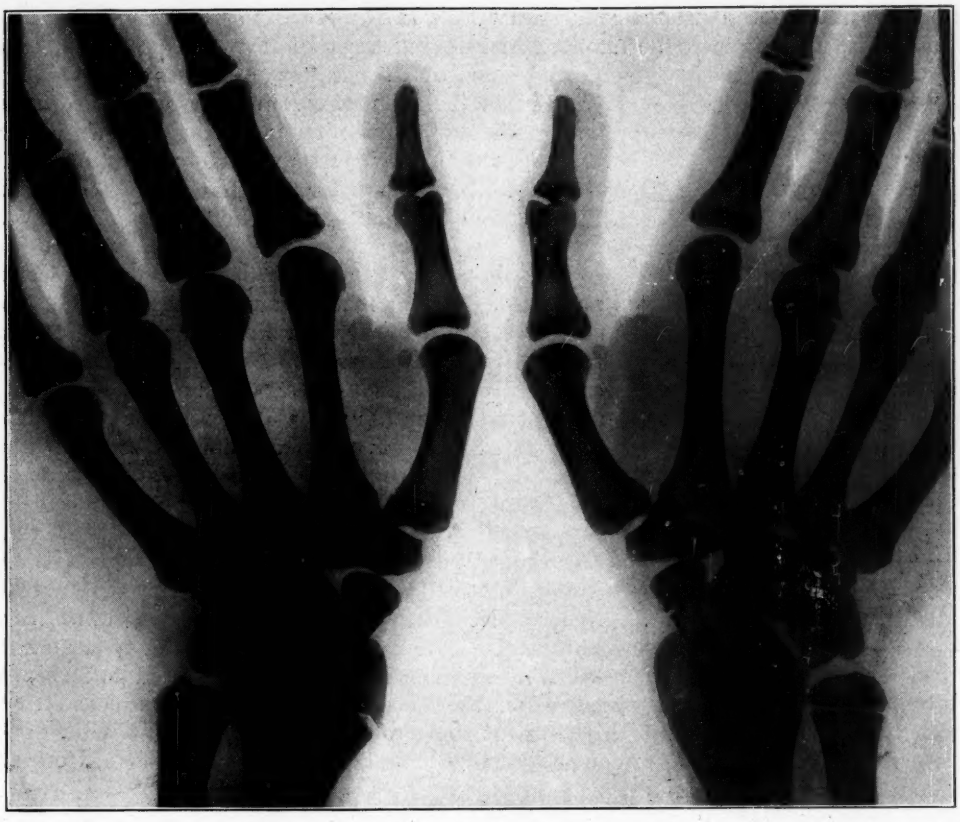


FIG. 6.—Showing a simultaneous fracture of the right scaphoid and of the lower left radial epiphysis. The vertical crack through the latter is not well seen here, but is quite distinct in *Fig.* 7, taken from the same patient. (Note how well the scaphoid is seen when photographed with the hand adducted.)

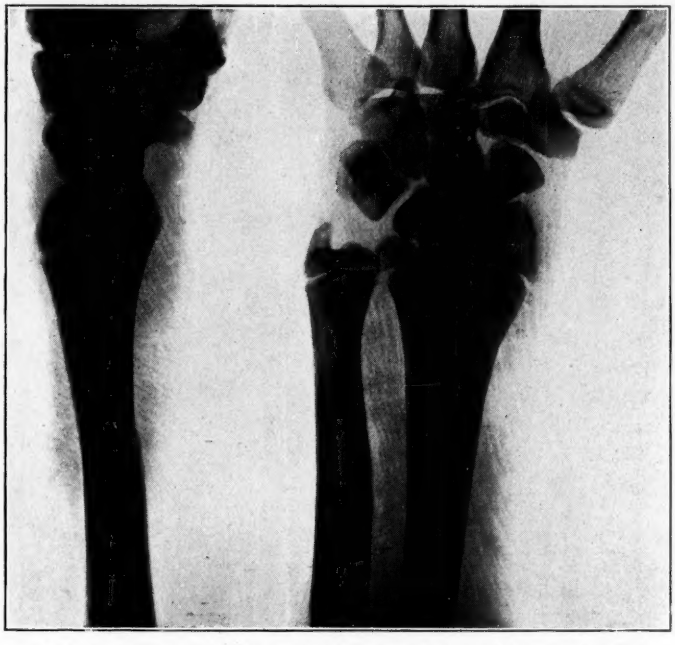


FIG. 7.—Fracture of right scaphoid, and vertical crack through lower epiphysis of left radius.

FIG. 8.---Normal carpus in abduction, or radial deflection.

Codman and Chase,[11] in their classical article in the *Annals of Surgery* for 1905, lay down a precise technique to be adopted in *x*-raying cases of fractured scaphoid, or suspected cases of that injury; they say that the two hands should be placed side by side, palms downwards, and with the thumbs as close together as possible; the hands should be as much ulnar-deflected as possible, the tube placed on a level with the knuckles, and in this position the photograph should be taken (*Fig.* 6). Further, views should be taken with the palms supinated. It is hardly necessary to add that plates should always be taken; mere examination with the fluoroscopic screen is totally unreliable for the detection of these fractures in all cases. Nevertheless, in a doubtful case, screen-examination should be employed as an adjunct to the taking of plates, and for this reason: the line of fracture, when the bone is broken through the waist, as it usually is, is not always just at right angles to the surface of the couch and to the incident ray, even when the hand is held in the standard position. The rays therefore have to travel through a normal thickness of bone, and the existence of a linear fracture may quite easily be overlooked in consequence. If, however, the wrist is slowly turned from the fully-supinated to the fully-pronated position, there must be, at some stage, a moment when the rays will pass through the small space between the fragments, and at this moment the observer will see a bright band of light on the screen. (This applies, of course, only to recent fractures, before callus-formation has taken place.) (*Figs.* 11–13.)

FIG. 9.—A 'notched' scaphoid, i.e., a view in which the foreshortened tuberosity is superimposed upon the shadow of the remainder of the bone.

The proper routine to be observed, then, in *x*-raying a recent fracture of the scaphoid, consists in: (1) Fluoroscopy, in all positions between full supination and full pronation;

FIG. 10.—Vialle's fracture, i.e., fracture of posterior lip of lower end of radius by force transmitted through the scaphoid.

(2) Taking plates of both wrists, in Codman and Chase's standard position, one set with the palms turned up, and the other set with the palms turned down; (3) Occasionally, when the fracture of the scaphoid is merely part of a complicated injury of the carpus, it may be well to take stereoscopic pictures of the wrist; in such a view the bones stand out very perfectly in relief, and a very beautiful view of the carpal tunnel is secured.

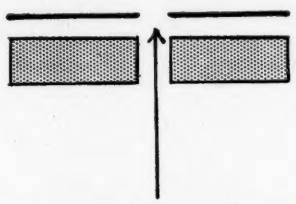


FIG. 11.—Diagram showing how the *x*-ray passing vertically through a fracture of the scaphoid produces a clear band of light across the shadow on the screen.

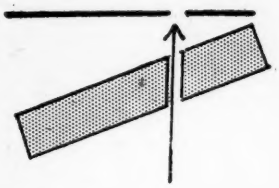


FIG. 12.—Shows how oblique fracture can be demonstrated by rotating wrist.

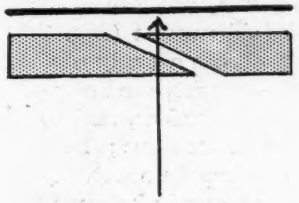


FIG. 13.—Shows that no clear band will be seen if the incident ray does not pass vertically through fracture.

This discussion on the radiography of the scaphoid leads up to the question of variations in the position of the scaphoid in accordance with variations in the position of the hand as a whole. This is of more than merely academic or radiological importance, for it has a very practical bearing upon the mechanism of the production of fracture, or, rather, of the various fractures. The question has been studied by dissections, both in the cadaver and in the living patient, but by far the best idea can be obtained by carefully studying a series of stereoscopic views of the carpus, taken in various positions. To anyone who has not tried this method, it will come as a revelation; the views obtainable are very beautiful, and give one a wholly new conception of what happens to the various parts of the carpus during various movements. Moreover, the results thus obtained are necessarily much more reliable than those obtained under the very artificial conditions of dead-house dissection, where all the surrounding soft parts have to be cut away before the bones can be studied.

The first and most obvious fact that we note about the movements of the scaphoid is, that when the hand is radially deflected (or abducted) it slides well under cover of the lower articular surface of the radius (*Fig.* 8), whilst when the hand is ulnar deflected (or adducted) the scaphoid is dragged out of this cover, and becomes perhaps more exposed to injury (*Fig.* 5). In many radiograms it even appears that the scaphoid tends to leave the radius, so that there is a clear space seen between the lower border of the radius and the upper border of the scaphoid, whilst there is evidently an ample radiocarpal space in which the scaphoid can lie (*Fig.* 5).

FIG. 14.—Normal carpus, in extension.

When the hand is radially deflected, however, the scaphoid is thrust up against the radius, and the radiocarpal space for the bone is minimal. Over and above the purely lateral movement of the scaphoid, Nogier[48] has described a 'pseudo-luxation' of the bone, by which he means an anteroposterior tilting of the scaphoid during radial deflection; the bone tilts in a dorsi-palmar direction, so that the tuberosity comes forward and appears much more foreshortened than it really is; in other words, in abduction of the wrist the scaphoid comes to lie much more nearly

at a right angle with the long axis of the forearm than it normally does. (In its normal position, it makes an angle of about 45° with the long axis.) This increased tilting of the bone with radial deflection of the wrist explains of course the superimposing of the shadow of the tuberosity upon that of the body of the bone, as explained above (*Figs.* 8, 9, and especially *Fig.* 24). If the wrist-joint be extended, the tilting goes a stage further, and the scaphoid comes to be practically perpendicular to the long axis of the forearm, and lies in close contact with the lower articular surface of the radius and its styloid process (*Fig.* 14).

From a study of the radiograms here reproduced it is easy to see that, in all positions of the wrist, the body of the scaphoid continues to act as a buffer between the os magnum and the radius, and to transmit force to the radius from the outer column of the carpus and metacarpus; however much it may project, at least the bone never escapes from its radiocarpal pocket. In certain positions the body of the bone must obviously be pinned very securely between the radius on the one side and the os magnum on the other, whilst the projecting tuberosity is subjected to various forces, direct or indirect, by which fracture may be produced. Moreover, the scaphoid is adapted to act as a buffer, not only because of its position, but also in virtue of its very structure, for it is mechanically weaker than either the radius or the os magnum; it serves admirably, therefore, to dissipate force transmitted through it, but is liable to suffer in the process. In order to allow of a certain amount of gliding during this force-dissipating or force-distributing process, the scaphoid is left by nature comparatively free from attachments: it is anchored to the os magnum and to the semilunar by an interosseous ligament; but it is quite free from the trapezium, the trapezoid, and the radius, whilst none of the thenar or any other muscles are attached to it, and the anterior annular ligament is attached only to the proximal part of it. We shall see, later, that this comparative detachment from neighbouring structures, though no doubt it has its advantages, has also a great deal to do with the marked tendency to non-union which fractures of this bone display.

There has been much acrimonious discussion as to whether all those cases in which a radiogram clearly shows a partition of the scaphoid are really cases of fracture. Many authorities maintain that there exists a condition of bipartite scaphoid, which is quite independent of fracture, and is probably a developmental freak. Their opponents contend that all the cases described as bipartite scaphoids are really cases of old ununited fracture. No doubt fracture of the scaphoid does frequently occur in cases diagnosed and treated as sprains of the wrist, and non-union inevitably follows; a pseudarthrosis develops between the fragments, and if there is little or no callus exuberance, and little arthritis, it is very easy indeed to mistake the radiographic appearances for those of bipartite scaphoid. It is assumed that in many of the cases described as bipartite scaphoid there was really a fracture, and that the accident has been forgotten. But even allowing for the extraordinary stupidity and forgetfulness of some classes of patient (so that one has even seen cases of bony ankylosis of the hip in wlich no history of previous pain or illness could be extracted), it is almost inconceivable that a grown-up person could completely forget the accident that would lead to a fracture of the carpus. The youngest age at which this fracture has been recorded is 15 years, and the average age is 24 years. It must not be forgotten that these fractures only occur in adults, and only after considerable violence. Nevertheless, it cannot be denied that nearly all the 'bipartite scaphoids' that have been described have been found in cadavera, and that a routine search amongst live patients, by means of the *x* rays, fails to reveal the condition in anything approaching the frequency which the champions of the bipartite bone assert to be normal. They say that bipartite scaphoid occurs in ½ per cent of normal human beings, and that the bone is partly cleft in as many as 2 per cent. In not one of all the radiograms examined in connection with this article has any example been found, nor can I remember ever to have seen one whilst examining wrists with the *x* rays for any purpose whatsoever.

But though we may not concede that partition of the scaphoid is common, we can hardly deny that it sometimes occurs. There is much evidence, hard to controvert, to show that it does. In the first place, partition of the scaphoid is almost always bilateral,

whereas fracture of the scaphoid rarely is (only 1 in 18 cases). Next, it has been demonstrated by quite a number of independent observers, including Rambaud, Rénault, Bardeleben, and Thilénius, that there are often two, and occasionally even three, ossific centres in a human scaphoid ; normally these unite and form one, which is clearly seen with *x* rays at six years of age, but remains cartilaginous and cushion-like up to sixteen years, and then begins to ossify throughout. It is easy to appreciate that sometimes these separate ossific centres might fail to unite in the ordinary way ; sometimes they fail entirely, when the condition of bipartite scaphoid is produced, and sometimes they fail partially, when there is produced a cleft or notched scaphoid. The statement that the scaphoid might sometimes be bipartite seems to have been made first of all by Wenzel Grüber, in 1865 ; but the first really authoritative work on the subject was that of Pfitzner, published in 1900 ; he investigated 1456 wrists from this particular point of view, and found amongst them 9 cases in which the scaphoid was completely bipartite (7 left and 2 right), and 29 cases in which it was partially cleft (15 left and 14 right). In these cases, the outer bone articulates with the os magnum, trapezium, and trapezoid, and the inner articulates with the radius, semilunar, and os magnum ; this arrangement is constant. The outer part is to be regarded as the true scaphoid, and the inner as a metascaphoid. Sometimes there is an os centrale as well in these cases, and it may either be present as a separate bone, or may be fused partly or completely with the radial or true scaphoid. In Pfitzner's article will be found a full bibliography of bipartite scaphoid. It also includes a romantic account of the discovery of the first os centrale ; the distinguished morphologist, Dwight, had prophesied its existence long before any example of it had been found, basing his assertion on studies in comparative anatomy, and on the examination of the carpus in the skeletons of prehistoric men ; years later, the os centrale was discovered by the aid of *x* rays in a living man's hand. The whole story reminds one of the foretelling of the existence of various chemical elements and their physical properties from a study of the atomic series, and the ultimate discovery of each of them. The existence of iodine, for example, and its properties, were forecasted successfully in this way, and the same is true of several of the rare metals lately discovered.

Pfitzner worked out a sort of schema of the human wrist, in which there appears not only an os centrale, but also an os scaphoideum radiale and an os scaphoideum ulnare ; this schema was based on comparative anatomy. The os centrale has been shown to exist ; enthusiasts will probably say that this is an argument in favour of the other bones also existing, and they will say that the bipartite scaphoid is the living representation of the theoretical os scaphoideum radiale and the os scaphoideum ulnare. In actual fact, however, the bipartite scaphoid has not been demonstrated as often as one would have expected ; Pfitzner says that he found the bone completely cleft in ½ per cent of all wrists examined in his series of 1456 ; Codman and Chase,[11] however, " did not find a single divided scaphoid that was not definitely associated with injury " in a series of 1040 wrists that they examined. They therefore consider that bipartite scaphoid is so rare that it cannot be held to account for the comparatively common cases of apparent fracture (amounting to ½ per cent of all fractures, in fact). Another important point is that, at operation, the adjacent surfaces of the bones are always found to be rough, and to consist of cancellous bone ; whereas, in true bipartite scaphoid, articular cartilage would always be found clothing them, and it would be perfectly smooth and glistening.

The lack of confirmation for Pfitzner's findings is a very telling point against those who believe in bipartite scaphoid, for an ounce of practice is worth a pound of theorizing ; nevertheless, there are certain other points to be borne in mind which support their claims to some extent : (1) The condition is sometimes associated with other developmental anomalies, such as webbing of the fingers, premature synostosis of the phalanges. If one developmental peculiarity exists, it rather strengthens the belief that any other abnormality present is of developmental origin also. (2) In a fair proportion of cases (though not in many of Pfitzner's) the condition seen is bilateral, whereas bilateral fracture of the scaphoid is admitted by every one to be exceedingly uncommon. (3) Complete absence of any history of injury—we have dealt with this point above.

To sum up, I think we must admit that the evidence is so strong, and the arguments are so good, that one cannot deny that partition of the scaphoid does sometimes occur as a developmental reversion ; but it is probable that many, and perhaps most, of the cases actually described have been ordinary cases of 'missed' fracture of the scaphoid. The truth lies, as usual, midway between the two extreme views that have been put forward.

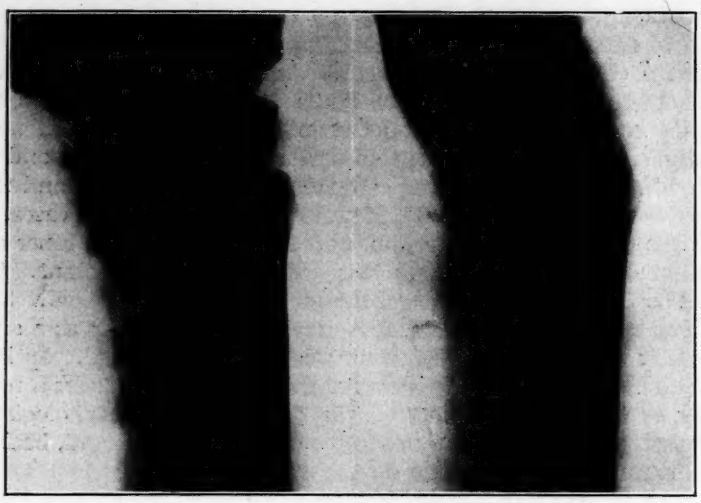


FIG. 15.—Comminuted scaphoid and oblique fracture of lower end of radius (involving articular surface). Anteversion of fragment. Direct injury.

Next, let us study the radiographic appearances of the various types of fracture that occur, and consider how they are produced. The ordinary text-books talk about 'fracture' of the scaphoid, but there are in reality several perfectly distinct varieties ; this is why the present article has been entitled, "Fractures (and not Fracture) of the Scaphoid".

FIGS. 16, 17.—Transverse or 'snapped-waist' fracture of scaphoid, produced in abducted position of carpus, as always.

The several types connote several different mechanisms, and, armed with a precise knowledge of the normal anatomy and function of the scaphoid, it should not prove difficult to work out these mechanisms.

The commonest fracture is a clean snap across the waist of the bone. Usually the

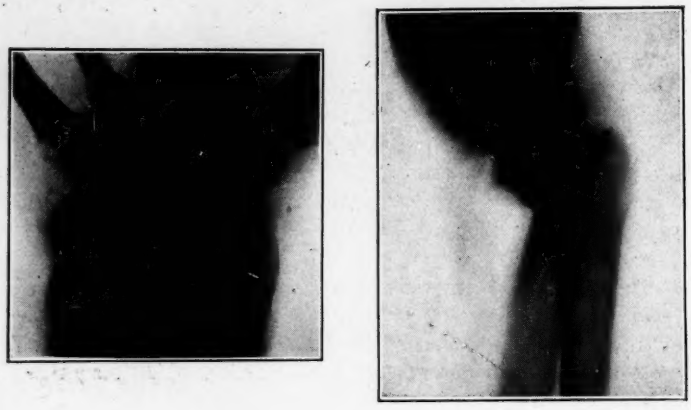
break is at the middle of the bone, which is its slenderest part, but sometimes it is nearer to one or other end. Obviously this difference depends upon the position in which the bone (i.e., the carpus) happens to be held at the time of the injury. It is also evident that the fracture must be produced by an indirect force, of the snapping variety, and not by a crush or other direct injury, One part of the bone, presumably, must be tightly gripped, whilst force is being applied to the other part. Two-thirds of all fractures of the scaphoid are of this 'snapped-waist' variety (66 per cent to be precise) (*Figs.* 6, 16, 17, 18). When a clear account of the accident can be obtained, it is always to the effect that the hand was abducted at the time. We saw, it will be remembered, that when the hand was abducted, the scaphoid was firmly jammed between the os magnum on the one side and the lower end of the radius on the other; also, we saw that in this position the scaphoid became more or less vertical, and whilst in this position it served as a buffer to dissipate force applied to the distal part of the hand, i.e., the carpus or metacarpus. The dorsal part of the bone is very firmly held, but the palmar end is held less firmly, and projects somewhat from the radiocarpal socket (*Figs.* 6 and 16); therefore the scaphoid yields at its weakest point, viz., the middle. In other words, the line of fracture usually continues the midcarpal interline. If abduction is less extreme at the moment of impact, the fracture will be nearer to the ulnar end of the bone. A fall upon the outstretched hand is the commonest type of accident, but backfires when starting up motor cars are sometimes held responsible. At any rate, the violence is always applied indirectly. Of all the authors who have written on fractures of the scaphoid, de Fortunet alone thinks that direct injury (*Fig.* 19) is a common mechanism, and certainly it cannot be the mechanism of the snapped-waist variety, which is the commonest fracture. Speese[64] talks of two kinds of transverse fracture (i.e., 'split-waist' fractures), one associated with compression, and the other without it. It is conceivable that at the extreme limit of radial deflection of the hand the scaphoid might impact upon the styloid process of the radius (*Fig.* 8), and, if it failed to break it, it might itself be somewhat crushed together and compressed in the process; but this seems improbable when we recall the vertical pseudo-luxation which occurs in the scaphoid in this position. It is far more likely that the apparent 'compression' is simply callus resulting from the repair of an ordinary transverse fracture. I have yet to see a recent fracture of the scaphoid, produced during abduction of the hand, in which the immediate radiogram shows any sign of compression.

FIG. 18.—Old fracture of waist of scaphoid.

FIG. 19.—Comminuted fracture, produced by direct injury.

Radial deflection of the hand, together with some degree of extension of the wrist-joint (such as occurs in falls upon the outstretched palm), is responsible not only for transverse fracture of the scaphoid, but also for a certain fracture of the radius which, as far as I can discover, was first accurately described by Vialle, of Lyons. I mean the very

characteristic fracture of the posterior lip of the lower articular surface of the radius; it is a fracture which is very constant in type, and quite familiar to anyone who sees a number of forearm fractures, but its mechanism, and the part played therein by the scaphoid, have not hitherto been clearly described and appreciated. The splitting-off of the piece of radius usually follows a line that runs obliquely upwards and outwards, as one would expect, seeing that the hand is abducted at the time of impact (*Fig.* 10). A lateral view, in these cases, will show that it is only the posterior lip of the radius that has been chipped off and displaced, and not its whole thickness. Sometimes the scaphoid breaks the radius as it strikes it, but escapes injury itself, as in *Figs.* 10 and 24; at other times both bones may be broken, as in *Figs.* 20 and 21; whilst on other occasions it is the scaphoid alone which gives way; no doubt this is partly due to its being structurally weaker than either the os magnum or the radius.



FIGS. 20, 21.—Fracture of scaphoid, and of radius by scaphoid (a severe degree of Vialle's fracture).

Another variety of injury which occasionally occurs in association with fracture of the scaphoid is fracture of the lower radial epiphysis. An example of this is seen in *Fig.* 7, which shows a definite vertical fracture without displacement through the lower epiphysis of the left radius; in this same patient there was produced simultaneously a fracture of the right scaphoid. *Fig.* 6 is another view of the same patient, taken with the two wrists side by side, and in this picture the existence of the fracture of the radial epiphysis is masked by the overlapping of the semilunar. This illustrates the importance of taking several views at various angles in difficult cases of fracture about the carpus.

Of those who have written about the mechanism of fracture of the scaphoid, Vialle,[66] Princeteau,[57] John B. Murphy,[47] Jaboulay,[32] and Destot[15,16] have all taken the view that fracture was normally produced by a fall upon the abducted hand.

Fracture also occurs in adduction, or ulnar deflection, of the hand, but this is much less common. The usual form of violence is a backfire, so that we have a combination of ulnar deflection and forcible extension of the wrist-joint. This may produce sudden extreme tension of the external radioscaphoid ligament which is attached to the tuberosity of the bone, and this may be avulsed; the fracture is perfectly characteristic, and if one knows accurately the nature of the force applied, the existence of a fracture of this type can be prophesied safely (*Fig.* 22). This is not at all a common form of fracture of the scaphoid; it has been described by J. B. Murphy,[47] and also by Speese,[64] thus making three types described by the latter author, viz., the transverse fracture with compression, the transverse fracture without compression, and the avulsed-

FIG. 22.—Fracture of the 'avulsed tuberosity' type, produced in adduction or ulnar deflection of carpus.

tuberosity type. When extension of the wrist is extreme, impaction may occur, or sometimes comminution, from compression. McCarty[39] alone thinks that ulnar deflection is the commonest mechanism of fractures of the scaphoid; he thinks that it is in this position that the ordinary 'snapped-waist' type is produced; he argues that in ulnar deflection plus hyperextension of the wrist, the scaphoid projects beyond the radius; the distal end is firmly fixed by ligaments, but the proximal fragment is mobile, being articular, and attached solely to the anterior annular ligament; therefore, he says, it is between the two that the bone gives way.

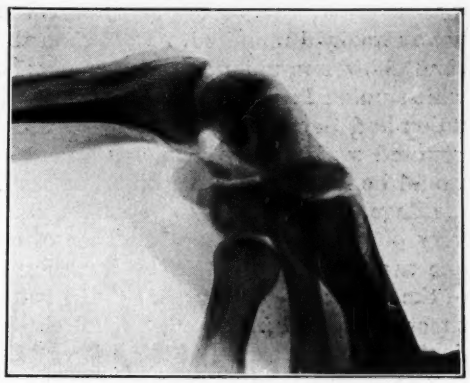


FIG. 23.—Normal carpus in hyperflexion.

The third, and by far the rarest, mechanism consists in fracture of the scaphoid during hyperflexion of the wrist. In this position (*Fig.* 23), the two rows of carpal bones try to separate from one another; the tendency is for the first row of bones to move forwards and the second row backwards; the radio-carpal socket of the scaphoid is widely opened up, and as the bone is only supported behind by the tendons of the extensores carpi radialis longior and brevior, it follows that very often it becomes dislocated. Such a dislocation is, in fact, but the first stage of an intercarpal dislocation. In other instances, however, the scaphoid is broken, the reason being that the bone in this position practically enters into the formation of both rows of the carpus; and it naturally follows that if one part tries to move in one direction, and the other part in the reverse direction, fracture must ensue. MacLennan[40] has advanced the view that fracture of the scaphoid is usually produced during hyperflexion of the wrist, the lower or most posterior part of the joint receiving the main impact; in such a case there may be fracture of the lower part of the radius as well; Vialle[66] and Vallas have recognized that fracture may be produced in this way, though they do not go so far as to say that it is the common way. In the Guy's series there has been no example of an injury of this type.

FIG. 24.—Fracture of radius by scaphoid. Vialle type.

A knowledge of the mechanism of production of the several fractures of the scaphoid is of more than academic interest, for it will help to put us on our guard in their diagnosis. If, in examining cases of injury of the wrist, the likelihood of fracture of the scaphoid is always borne in mind, it is most improbable that such a fracture will ever be overlooked. Moreover, when the three cardinal signs of the fracture are present (viz., acute local tenderness, limitation of extension of the wrist, and œdema running up the dorsum of the wrist in its outer half, along the tendons), one can go further, and say that fracture of the scaphoid is actually present.

In all the recent cases that I have seen, the diagnosis was definitely determined on clinical grounds before an *x*-ray picture was made, and in every case the diagnosis was confirmed. Furthermore, in no case has a diagnosis of fracture of the scaphoid ever

been made without its being subsequently proved to be correct. In some cases, when the exact position of the hand at the time of impact can be elicited, one can go even further with the elaboration of the diagnosis, and predict from the mechanism the exact type of fracture that will be found.

A radiogram cannot be regarded as an infallible means of determining whether a fracture of the scaphoid has united or not, but in many cases it gives a very clear indication, and conclusions drawn from radiograms have frequently proved at operation to be quite correct. The commonest observation that one makes, in old fractures, is that they have remained ununited. More than three-quarters of all the old cases seen at the present time show non-union, and it appears, from a comparison of these cases with others in which union has taken place, that the greater part of their disability is due to the non-union and the secondary results to which it gives rise. At operation it is found that the opposed surfaces of the pieces are not covered with smooth articular cartilage (as they would be in cases of true bipartite scaphoid), or with glistening fibrous tissue, or pseudo-cartilage, but that they are rough, and grate when rubbed together; moreover, there is very often some slight exuberance of callus upon the articular surfaces of the bone, and one can well imagine that such a rough material, scraping against the polished lower end of the radius, might cause a sudden twinge of pain, and make a man drop his tools. Sometimes there is definite evidence of chronic local arthritis of the joint in the shape of reddening and thickening of the soft parts, and a slight increase in the quantity and viscidity of the synovial fluid. Not only inside the joint, but around it also, there may be evidence of chronic irritation; if so, the prognosis is so much the more grave, for in this, as in all articular and para-articular fractures, the effect of the injury upon the joint is far more important than its effect upon the bone itself. It is often said that the chief reason for the non-union is deprivation of blood-supply, consequent upon the injury; but as the scaphoid normally receives its main blood-supply by way of the ligaments attached to it, and as these are seldom or never ruptured, it is rather difficult to see how this oft-repeated explanation applies.

Preiser[56] has contributed some interesting cases, in which he has shown that injury of the wrist may be followed by a central absorptive process going on in the scaphoid, the so-called 'rarefying osteitis', and a bone thus weakened may subsequently undergo pathological fracture; he suggests that the area of increased transradiancy seen in his *x*-ray photographs is due to absorption of the bone caused by rupture of the nutrient blood-vessels. His pictures show the central areas of absorption in these damaged, but unbroken, scaphoids very clearly, and one can easily imagine that after fracture a similar absorptive process might go on in the two halves of the bone, and lead to non-union and formation of a pseudarthrosis between them. In a few cases where the bone was excised a few days after fracture and carefully sectioned, it has been found that the middle of it was occupied by recent clot and liquid blood; in others, cystic degeneration has been described, and has been attributed to osteitis fibrosa following the injury.

Seeing that the normal nutrition of the scaphoid is by way of the ligamentous structures attached to it, and that these are rarely detached, it seems difficult to adopt a purely vascular lesion as the explanation of the frequent non-union. It seems much more likely that the fact of the fracture being entirely intra-articular has a great bearing upon the question. It is always bathed in excess of synovial fluid, and we know, from the analogy of other joint-injuries, that synovia does tend to exert an inhibitory action upon plastic processes. Indeed, in a normal healthy joint that is one of its most important protective functions. A third factor that plays a large part, no doubt, in producing non-union is undue mobility, for, as we have seen, most of these fractures are overlooked and not adequately rested.

One English author alone, as far as I can discover, advocates massage and mobilization from the very first; he says, writing in 1911, that carpal fractures occurring alone need no splint; that a large degree of freedom can be permitted from the outset; also, that bony union is the rule; that restitution of functional utility should be complete in three

weeks; that the formation of callus, given proper massage treatment, is unknown, and that even if bony union fails to occur, the patient suffers no inconvenience. The majority of surgeons hold diametrically opposite views. As regards the scaphoid, at any rate, it is held that early movements are one of the main causes, if not the most important cause, of non-union. And certainly, if we examine our patients' histories carefully, non-union does involve a very grave disability in the majority of cases; the hand is painless if kept still, but is weak and untrustworthy in use. As Codman and Chase[11] say, "If the fracture remains ununited, the permanent disability is so great that it seriously interferes not only with the comfort of the patient, but with his ability to enjoy certain games and sports, and also, in the case of working men, it limits their working capacity, and hence their ability to earn their living". These writers found only three cases out of their series of thirty in which the wrist had been kept on splints for a time, and in all three bony union had taken place; and, in our own series, union has occurred in all the recent cases, after three or four weeks' rest upon a wooden or metal 'cock-up' splint. There is therefore considerable evidence to show that early movement, in the case of this fracture, is most prejudicial, and largely responsible for the production of the non-union. One must, of course, go a stage further with the argument, and inquire whether non-union is the chief reason for the disability, and whether function is always good in those cases in which union has taken place. It will be found, on investigating the after-histories of a series of patients, that function is always very much better in the united than in the non-united cases; in the writer's experience, the average time taken before a man was able to resume his full work was about eight weeks after the splints were removed, i.e., eleven to twelve weeks from the time of fracture. This may seem rather a long time, but it must be remembered that the majority of these patients are men whose occupations are laborious, such as that of stone-mason, 'bus conductor, wheelwright, etc. Moreover, twelve weeks is not a long time to spend on getting an injured wrist well, if the alternative is a joint that will be troublesome for the rest of the man's life.

As a routine treatment for a recent case, therefore, we strongly advocate preliminary splinting for three or four weeks, followed by mobilization and the employment of all the usual physiotherapeutic measures, such as whirlpool baths, contrast baths, or radiant-heat baths. The writer has not been able to make out that the results of four weeks' fixation were any better than those of three weeks' splinting, and has therefore adopted the shorter period; and as regards the type of splint to be employed, a long 'cock-up' has been uniformly used, on the principle that if stiffness should ensue, it is better to have the wrist stiff in extension than in any other position, because that is its position of activity.

Absolute immobilization, in the strictest sense of the word, has not been attempted, nor has it been found necessary; resting the fingers and wrist upon a full-length 'cock-up' splint for three weeks has proved sufficient to ensure bony union; massage upon the splint has been employed after the first week, with the object of promoting absorption of inflammatory products, allaying spasm of muscle, and improving the blood-supply.

The principle of treatment, then, is very like that which we adopt in the much more common injury, the so-called separation of the lower humeral epiphysis; that is to say, we rest the parts at first, in order that over-production of bone within the joint may be avoided, keeping the joint meanwhile in the position of maximum usefulness; then, when the hyperæmia and other callus-promoting conditions have subsided somewhat, we proceed to restore mobility and function generally.

Generally speaking, the functional result is good in cases of fracture of the scaphoid when this principle is followed; in some few cases it is not, and in these as well as in a number of cases in which the initial treatment has been faulty, operation has been tried. A large number of such cases have been recorded, and the results seem to have varied enormously. Some authors say that their functional results have been perfect; others, that they have effected little or no improvement; and many take a sort of mid-position,

claiming that if they have not cured their patients, they have at least given them more useful wrists. One writer, for instance, says, "Operation will ultimately give a good joint. It will not result in a wrist of normal strength and flexibility, but it will give a strong painless joint which is limited in the extremes of motion. When disability is pronounced and the hands are constantly used, the benefit from relief of pain may be sufficient to warrant risking a loss of strength".

There can be no doubt, at any rate, that the results of operation in late cases of fracture of the scaphoid often leave much to be desired, and it is quite impossible for a surgeon to guarantee restoration of function to a patient to whom he is proposing operation. In many of the published cases of excision of one or both of the fragments, there has remained a marked degree of stiffness of the wrist, or of loss of power; several authors give some indication of the amount of permanent disablement when they say that they assess it as 30 per cent, or that the patient was only able to lift three or four kilos with the injured hand, whilst he could lift thirty to forty with the good hand. And there are undoubtedly many cases which have not been published, in which excision of one or both fragments has failed to effect much improvement. If relief of pain be all that the surgeon hopes to attain by operating, then the same result can be secured much more simply by providing the patient with a blocked-leather case, enclosing the forearm and wrist, by which means painful extension and sudden wrenches will be avoided.

The reason why operation has often failed and yet sometimes succeeds is not far to seek; it is simply that it is often carried out too late. The disability, as we have seen, is due to the arthritis and peri-arthritis, and not to the non-union *per se*; and if the fragments are not removed till the arthritis has been set up, and the arthritis persists, it is clear that such an operation must be foredoomed to failure. Operation can only succeed if it is done early. The proper course is to try splinting for three weeks, followed by massage, mobilization, and physiotherapy for anything up to three months; and if, by that time, function has not been restored and the patient still complains of pain on movement, it is probably wise to advise operation forthwith. Codman and Chase quote the case of a surgeon, in which early operation was performed with the most gratifying result; and Pförringer[34] mentions another, in which excision of the whole scaphoid was followed by complete disappearance of pain, and the patient was enabled to lift and carry a 50-lb. weight without difficulty.

It is quite clear that late operations are almost always disappointing, and that, if operation is to be employed at all, it should be before the condition of chronic arthritis has been set up.

The technique of the operation is quite simple, and it can, if desired, be performed under local analgesia. An incision is made on the dorsum of the wrist, along the anatomical snuff-box; it is deepened, the radial nerve and artery being held aside; it goes down parallel with the tendon of the extensor carpi radialis longior, and to the inner side of it, care being taken to avoid opening its tendon-sheath; the bone having been removed, the skin is sutured, no attempt being made to close the joint-capsule. The wrist is bound up, and the patient is encouraged to make such movements as the bandages allow from the very first, and a little later on massage is instituted. It is apparently immaterial whether the whole scaphoid is removed, or only a part of it; the wrist is certainly not weakened in any perceptible manner by the removal of the whole bone, but the results of operation seem to have been as good when the proximal fragment alone has been excised.

The Lyons school of surgeons maintain that ablation of the scaphoid alone is 'quite inadequate', and that it has no effect upon the arthritis present—as one would expect. Vialle,[66] and also Vallas,[66] advocate formal excision of the wrist-joint, and describe their results as 'very good'. No details are given, however, and it is difficult to believe that such drastic treatment could really restore full function to a labouring-man's right wrist.

From all that has been written about fractures of the scaphoid, and the many conflicting accounts that have been given of the results of various treatments, one fact

emerges most clearly, viz., that all methods of late treatment are uncertain and unsatisfactory. It is evident that accurate diagnosis of the fracture in the first instance is essential to uniform success in treatment; and given that a surgeon knows that there is an intra-articular fracture present, it should generally be possible for him to devise such a plan of treatment as will result in bony union of the fragments without callus excess. In some few cases (e.g., those in which comminution of the bone is present), this may not be possible, and it is in these cases that early, or possibly primary, operation should be carried out.

The main object of this paper has been to show that fractures of the carpal scaphoid are really very characteristic, and have well-marked and almost pathognomonic physical signs; that they should always be diagnosed at the time when they occur, because it is only then that treatment is capable of restoring a useful degree of function; and, lastly, that failure to diagnose these fractures, though very common at the present time, is fraught with the most serious consequences for the patient, inasmuch as it means that he will almost certainly have a permanently crippled wrist, in spite of all the treatments that he may undergo.

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THE PALLIATIVE TREATMENT OF ANEURYSM BY 'WIRING' WITH COLT'S APPARATUS.

By Sir D'ARCY POWER, K.B.E., London.

Pathological aneurysms, the result of chronic inflammation of the large arteries in the chest and abdomen, are of so deadly a nature and run such a distressing course, that any means of relieving the symptoms, even temporarily, must be welcomed by every one who is brought in contact with the unfortunate sufferers, and the means is doubly welcome if it offers even a remote chance of a cure. I make no excuse, therefore, in directing attention to a method of relieving the pain which is so constant a feature of the disease.

The apparatus employed was invented by my former house-surgeon, Mr. G. H. Colt. Its object is to enable a known quantity of wire to be introduced into the sac of a aneurysm with the least disturbance of parts, the maximum of speed, and the certainty of asepsis. Entrance of wire into the aorta, which is known to have occurred in at least seven cases, is also prevented. The instrument (*Fig.* 25) consists of a trocar and cannula, a ramrod, a tube, and a wisp. The wisp consists of a number of fine steel wires soldered together at one end, each wire being curled over in a separate plane so that it readily expands as soon as it is set free from any controlling force, though under ordinary conditions the wires are packed together and the individual strands lie parallel to each other. The wisp, in fact, is like a miniature umbrella which has a constant tendency to remain open; the end where the wires are soldered together is the handle of the umbrella, and the individual wires are the ribs. Originally a double wisp or 'cage' with the wires soldered together in the middle (as illustrated) was intended to be used for a large sac; but it was found that the second half of the cage did not expand with certainty after its insertion, so that its use has been discontinued. Each wisp fits into a hollow metal tube—open at both ends—so fashioned that it can be fitted easily and accurately to the distal end of the cannula after the trocar has been withdrawn. It then forms an extension of the cannula. This tube holds the wisp in its compressed condition as a bundle of wires lying side by side. The wisps are made of different sizes for use with different-sized aneurysms. The amount of wire in each is known, and is always the same for the same size. Thus, No. 1 wisp has a total surface area of $1\frac{3}{4}$ square inches and is composed of 75 inches of wire; wisp No. 2—the one generally used—has a surface of $2\frac{1}{2}$ square inches and the total amount of wire is 105 inches; and wisp No. 3 has $3\frac{1}{2}$ square inches and consists of 150 inches of wire. The wires composing the wisps are dull gilt, and if they be examined under the microscope or passed through the fingers the gilding will be found to have made them slightly granular. This irregularity of surface is intentional, and enables the blood-clot to form more quickly and to adhere more firmly than if the wires were smooth.

Every part of the apparatus can be sterilized by being boiled, and the method of using it is very simple. Care must first be taken to ascertain that the wisp expands freely as soon as it leaves the tube. The skin over the most pulsatile portion of the aneurysm is divided, and the trocar and cannula are thrust into the sac. The trocar is then withdrawn, and a jet of blood issues with considerable force if the cavity of the aneurysm has been reached. The tube containing the wisp is then fitted to the projecting end of the cannula, and the wisp is pushed into the aneurysm by means of the ramrod. If this be done steadily and gently the wisp is entirely released and falls into the cavity of the aneurysm, the expanding wires first and the soldered end last. The cannula is then withdrawn, and the skin incision is closed with a single point suture if necessary. Hitherto,

each operation has been performed under a general anæsthetic, but I believe local anæsthesia would be quite sufficient in most cases. I began by making a considerable incision in order to expose the sac, but now I merely puncture the skin to prevent the point of the trocar carrying epithelial cells in front of it into the aneurysm.

Experience has taught me one or two points of importance in performing the operation. In the first place it is necessary to have a free jet of blood issuing from the cannula when the trocar is withdrawn; it is then certain that the whole thickness of the wall of the aneurysm has been pierced, and the wisp will be delivered into the fluid blood, for it will be useless if it merely lies in the active or pre-existing laminated clot.

The introduction of the wisp by means of the ramrod should be done deliberately, and the cannula withdrawn afterwards steadily and without jerking, or the wisp may jump out of the puncture, as happened in one of my cases (*vide* p. 29) when I attempted to operate too quickly. Even in a large thoracic aneurysm the wall of the sac is sufficiently elastic to prevent any escape of blood when the cannula has been withdrawn. This fact had to be learnt by experience. I feared at first that the puncture would

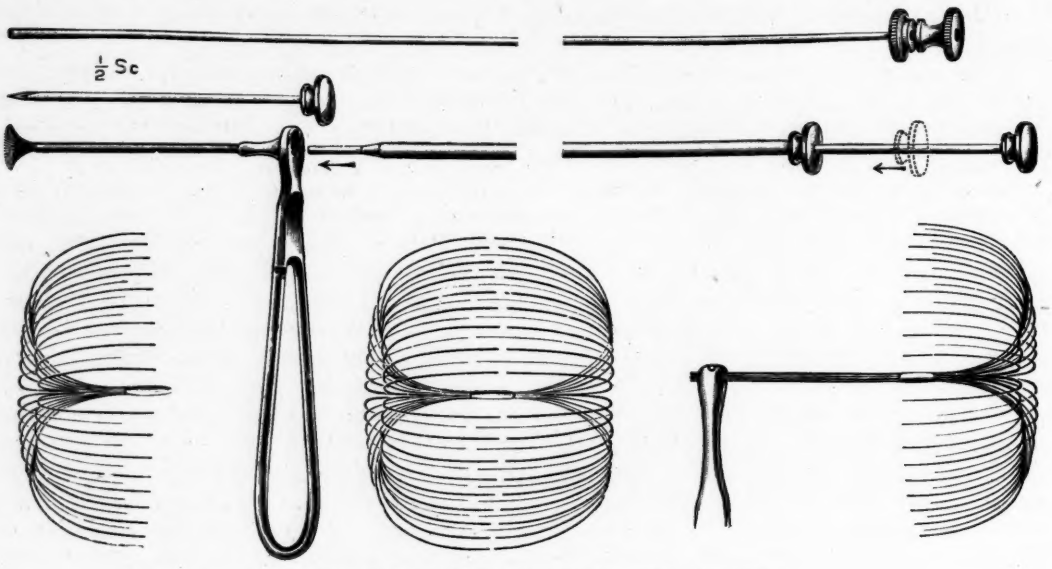

FIG. 25.—Mr G. H. Colt's apparatus for wiring aneurysms.

continue to bleed, and I used to suture the wall at the seat of puncture and reinforce it in the neighbourhood with a few additional sutures, until I saw this precaution was unnecessary, for there was no bleeding when the cannula was drawn out. I have, therefore, abandoned suturing in my later cases. The operation is attended with so little pain or after-disturbance that narcotics are often not needed; indeed it is better not to give them, because the patient has usually suffered so much that he craves for them, and the operation is a good opportunity to break him of the habit. Where the pain is severe, full doses of aspirin are usually sufficient, especially if the patient can be assured that within a few hours, or at most a day or two, the pain will disappear.

The following are details of my last three cases; the result of the third is still incomplete, for the patient is alive and doing her ordinary housework.

Case 1.—A shopkeeper, age 38, was admitted into St. Bartholomew's Hospital under the care of my colleague, Dr. James Calvert, on July 16, 1915. He stated that he had suffered from a pain in his chest for the last eighteen months, the pain having begun after he had made a sudden muscular effort. It gradually got worse, and during the last seven months it had been severe. He had kept his bed for the past seven weeks. He had served in the army, but on the whole had not led a strenuous life, and he had always been temperate. The patient was a tall, thin, and pale man, who lay curled up in bed on his right side. Movement caused pain in his chest which he said

was shooting in character and ran from the scapula down his back. It was made worse by coughing. The cough was dry, and in the later stages was accompanied by stridor; the breathing was oppressed, and deep inspiration caused pain. The pupils were equal and reacted sluggishly to light and accommodation. The Wassermann test was strongly positive.

A well-defined swelling could be seen pulsating on the right side of the chest. It extended from the margin of the sternum to the anterior axillary fold, and from the third to the sixth rib. The pulsation was expansile. Air entry over the right lung was diminished, and the percussion note was impaired all over the back, with occasional patches of bronchial breathing. The apex beat was in the sixth space, and was palpable from the sternum outwards for two inches. The heart sounds were muffled, and a systolic murmur was audible at the apex, in the epigastrium, and over the tumour. The liver reached an inch below the costal margin in the nipple line. The urine contained much albumin. *X*-ray examination showed a large saccular aneurysm of the ascending part of the arch of the aorta. On July 23, 1915, the patient being under a general anæsthetic, I made an incision ¾ in. long over the most prominent part of the swelling and punctured the aneurysm by means of Colt's apparatus. A No. 3 wisp was introduced, but on withdrawing the cannula the wisp shot out of the sac with considerable violence and fell on the floor. Fortunately I had another wisp ready sterilized, so I made a second puncture into the sac and introduced a wisp of the same size. Blood issued freely from each puncture when the trocar was withdrawn, but there was no hæmorrhage when the cannula was pulled out, so it was not necessary to suture the sac. The skin was closed with two point sutures of silkworm-gut.

The operation was followed by cough and dyspnœa. The temperature rose to 100·4° F. and the pulse to 120 for a few hours; but the temperature soon fell to normal and the pulse-rate diminished. The pain, however, was not relieved; the dyspnœa increased, and the swelling in the chest got steadily larger. The patient died eleven days after the operation. The post-mortem examination showed the body of a well-developed man with a marked swelling in the right pectoral region, over which was a small and recently healed wound where the aneurysm had been wired. The right lung was collapsed and was lying at the back of the pleural cavity. There were many adhesions of the right pleura, and the cavity contained blood-stained fluid. The chest contents, together with a portion of the thoracic wall involved in the swelling, were removed entire and sent to the museum to be hardened before a more detailed examination was made. The pericardium and heart were evidently not normal, and there appeared to be a large aneurysm of the ascending aorta which projected in part into the pericardium, but for the greater part was external to it and had 'bulged' the chest wall. The aneurysm had not ruptured. Subsequent inquiry showed that the specimen had neither been examined nor preserved. I think that I should have done better not to have operated in this case, but to have let the disease take its natural course. The patient was very ill, he was worn out by pain, and he had albuminuria. I hoped, however, that I might have relieved his pain.

Case 2.—A dock labourer, age 51, was admitted into St. Bartholomew's Hospital under the care of my colleague, Sir Percival Horton-Smith Hartley, on Jan. 14, 1916, complaining of a lump in the front of his chest. He said that in 1914 he had fallen down suddenly in the street whilst on his way home from work and had been taken to the London Hospital, where he was found to be suffering from left hemiplegia. He was kept in the hospital for sixteen days, and his left arm had remained weak ever since the attack. Eight months ago he began to feel a dull pain over the front of the chest, and six months later he noticed a lump in the front of the chest on the right side. The swelling had gradually increased in size. His voice was husky, but he had not experienced any trouble in swallowing. Examination of the chest showed many dilated veins with slight œdema. There was a visible tumour—showing expansile pulsation—situated to the right of the sternum. The note over the tumour was dull, the dullness extending from the second to the fourth rib, and for four inches to the right of the sternum. There was a systolic thrill and a murmur over the swelling, which *x*-ray examination showed to be an aneurysm of the ascending part of the arch of the aorta measuring 4½ inches vertically and 3 inches horizontally.

The patient was kept in bed under the care of Sir Percival Hartley from Jan. 14 until Feb. 21, on a light diet and with restricted fluids. He was given full doses of potassium iodide, as his Wassermann test was positive. The tumour increased in size steadily in spite of this treatment, and the patient complained bitterly of pain.

I wired the aneurysm on Feb. 21, 1916, using Colt's apparatus and introducing a No. 2 wisp, which presented a clotting surface of 2½ square inches and consisted of 105 inches of wire.

The patient being under a general anæsthetic, a semicircular incision was made over the tumour, beginning at the second right costal cartilage and extending downwards over the third costal cartilage. This was deepened until the pectoralis major was exposed; the fibres of the muscle were separated, and the sac of the aneurysm was seen as a bluish membrane of the consistency of thin parchment. The sac pulsated freely and it was obvious that it did not contain much clot. A trocar and cannula were introduced, and a full stream of dark-coloured blood spurted out for some distance as soon as the trocar was withdrawn. The No. 2 wisp was introduced without difficulty and the cannula was withdrawn. Blood still continued to issue from the puncture, which was closed with a single point suture of No. 2 silk on a round curved intestinal needle. The patient did not sleep much during the night, but he was fairly comfortable by eleven o'clock the next morning. He had a slight bronchitic cough which increased his pain.

The temperature was 99·4° and the pulse 84. On Feb. 24 he stated that he was free from pain, and on March 6 he left the hospital. The patient was seen eleven weeks afterwards, when the pulsation was found to be diminished, and on *x*-ray examination (*Fig.* 26) the shadow of the sac was darker than before and very little pulsation was observed in it. The relative density of sac and wire was slight, and the active clot must therefore have been only small in amount.

He was readmitted on Feb. 9, 1917, just a year later, saying that he went home sufficiently well to go back to work. In August, 1916, he was employed at Woolwich Arsenal sorting bullets—not an ideal occupation for a man with a large thoracic aneurysm. He worked there for two months, and was summarily dismissed when the Arsenal doctor discovered his condition. The diminution in the size of the aneurysm continued for some months, but in November, 1916, the swelling again began to get larger. The pain returned and his cough became more troublesome. He bore this for some months, but the pain and cough had become so much worse early in February that he came back to the hospital and asked to be readmitted for a further operation.

Examination of the chest showed that the respiratory movements were good, and equal on the two sides. There was a swelling over the second, third, and fourth ribs and costal cartilages.

FIG. 26.—Skiagram of *Case* 2, eleven weeks after operation. The arrows point to the ends of the wires forming the expanded wisp.

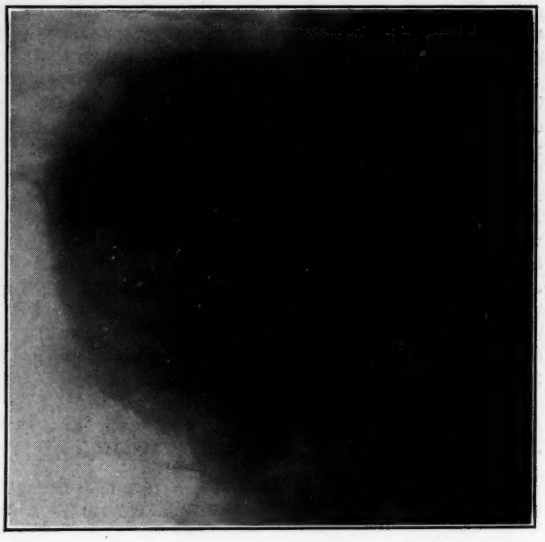

FIG. 27.—*Case* 2, a year after operation.

The swelling measured 2¼ in. in breadth and 3 in. in length. There was visible and expansile pulsation, and the percussion note over the tumour was dull. The tactile vibrations were diminished over the upper part of the right lung, and the breath sounds in that region were weak. The percussion note was impaired below; the bronchial sounds were harsh, and there were some bronchitic sounds. There was also a slight tracheal tugging, and the voice was hoarse. The pulse was regular and of full volume; the tension was increased, and the left pulse was slightly weaker than the right. Shortly after admission the blood-pressure in the right radial artery was 128 mm. Hg. and in the left 120 mm.; after a rest in bed for twelve days the blood-pressure was 105 on the right side and 115 on the left.

An *x*-ray picture (*Fig.* 27), taken on Feb. 13, showed a large aneurysm of the ascending arch of the aorta and a small bulge on the transverse portion of the arch. The wisp is clearly seen with the wires expanded, and the sac and its contents are much clearer than in the previous radiograph. The note states that the patient began to cough violently on Feb. 19 and brought up a small quantity of bright blood. The aneurysm increased in size during his stay in the hospital until it reached the sixth rib, but there were no physical signs of pressure within the chest, except that the bronchial sounds were greater at the right than at the left apex of the lung.

I again wired the aneurysm on May 2, using Colt's apparatus and introducing a No. 2 wisp. The patient made an uneventful recovery, and was discharged on May 30 with the note, "The pain is much less than before the operation, and the pulsation in the swelling is less marked". An *x*-ray plate, taken on June 2, just shows the wires *in situ* (*Fig.* 28), but it is not easy to determine the degree of expansion of the second wisp. The relative density of the sac and wire is much greater in this plate than in either of the two previous ones, and a considerable amount of clotting must therefore have taken place. The man only lived about a mile from the hospital and often came to report himself. He was able to do a little work as a night watchman until, on Aug. 27, 1919,

—forty-two months after the first and twenty-seven months after the second wiring—he fell down in the street on his way home from work and died the same night. There was no post-mortem examination, as we did not hear of his death until some weeks afterwards. A fourth skiagram, however, had been taken on Jan. 30, 1918 (*Fig.* 29), in which it is seen that the relative density of the sac and the wisps was not so great as it had been in June, 1917, which shows, perhaps, that the sac of an aneurysm fluctuates in size independently of any tendency to rupture.

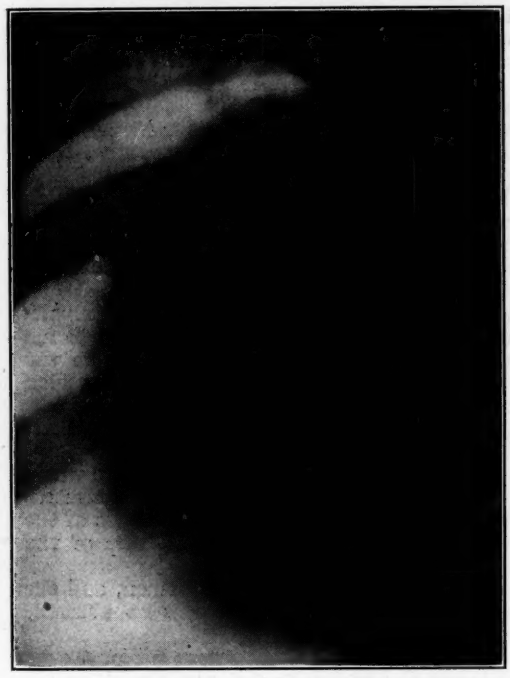

FIG. 28.—*Case* 2, one month after second operation.

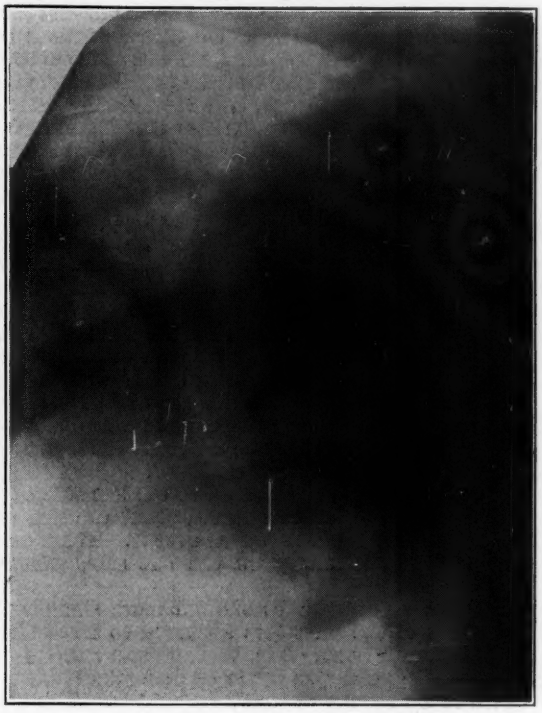

FIG. 29.—*Case* 2, eight months after second operation.

Case 3.—The third case was that of a married woman, aged 52, who was admitted into St. Bartholomew's Hospital on March 25, 1919, complaining of a constant aching pain in her chest. She said that she struck her breast accidentally about the beginning of December, 1918. The pain had been constant ever since, and was now getting unbearable. It was throbbing in character. Examination showed visible pulsation on the right side of the chest over the second interspace close to the sternum. The swelling was pulsatile. The chest-wall was so well covered that it was almost impossible to percuss out the heart. A diastolic and systolic murmur were heard at the apex, and there was a double aortic murmur. The Wassermann test was strongly positive.

The patient was kept under observation in a medical ward from March 25 to April 24, 1919, and during the whole of this time she suffered much pain in her chest in spite of all that could be done to relieve her.

On April 24 I wired the aneurysm under a general anæsthetic, using Colt's apparatus and introducing a No. 2 wisp at the point of maximum pulsation. The patient made an uninterrupted recovery, and a note written on June 30, 1919, records that there was much less pulsation over the swelling and the pain was greatly diminished.

The patient was readmitted to the hospital on June 8, 1920, saying that the pain had returned in November—five months after her discharge—and had again got gradually worse until she decided to apply for another operation. The blood-pressure in her right radial artery at the time of her second admission was 165–160 mm. Hg., and in the left radial 180–170 mm. There was no obvious tracheal tugging. Examination of the chest showed visible pulsation in the second right interspace, and the pulsation could be felt. There was also dullness over an area in the second right interspace close to the sternum. A double aortic murmur was heard at the base of the heart, and a diastolic murmur at the apex—systolic conducted (?) the note says. Both legs were œdematous, and the urine contained a trace of albumin.

The patient was kept in bed from June 30 until July 5, when I again introduced a No. 2 wisp by means of Colt's apparatus. The patient made a good recovery, and left the hospital on Aug. 19,

the last note recording that the pain was much less than it had been before her admission. At the present time (March, 1921) the patient is living and doing her housework.

My friend, Mr. G. E. Gask, D.S.O., C.M.G., allows me to publish the following case which was under his care at St. Bartholomew's Hospital :—

Case 4.—C. W., age 35, a cattle-rancher, was admitted on Sept. 19, 1919, complaining of continual pain in the small of his back, and periodic attacks of acute pain in the left hypochondrium. When the pain comes on in the left side he also feels a numb but burning sensation, and the skin becomes so sensitive that he cannot bear the weight of the bedclothes.

One day in May, 1917, he was twice thrown from a mule and much shaken, but it was not until two months later that he began to feel pain in the small of the back. The pain was at first slight and intermittent, but it gradually increased and was constant. The patient states that he lost weight at this time and that he often had cramp in his stomach.

He was admitted to a hospital in San Paulo in March, 1918, and was treated for rheumatism. He was discharged some weeks later feeling quite well. He remained well for three months, when the pain returned in the back and left side of the abdomen. The cramp in his stomach became bad, and he lost 10 kilos in weight. He was treated by a Spanish doctor for 'nodular peritonitis', and was subcutaneously injected, probably with tuberculin. The patient again improved and gained 8 kilos in weight. The pain, however, returned, and he determined to come to England. He arrived in September, having suffered severe pain during the last eight days of the voyage. He was passing blood and mucus by the bowel and had lost 4 kilos in weight.

Examination showed that the apex of the heart was in the fifth space internal to the nipple, and that the sounds were normal. The abdomen moved well ; there was no distention, but the upper third of the abdominal wall was rather resistant. There was a slight swelling in the epigastric region 2½ in. above the umbilicus and just to the left of the middle line. In this region there was a circular area about 2 in. in diameter where pulsation and a slight thrill could be felt. Expansibility could not be definitely made out, but there was dullness on percussion, and a systolic and diastolic bruit could be heard.

At the back, about 1 in. to the left side of the spine of the tenth dorsal vertebra, there was a small circular area of fullness, about the size of a half-crown, which was expansile and pulsated. A faint bruit could be heard over it. There was very great tenderness over the lower part of the abdomen, particularly on the left side, where the patient could not bear the pressure of the bedclothes.

X-ray photographs showed more shadow than normal in the right upper abdomen, and the shadows of the intestines appeared to be pushed away from this part. There was no evidence of erosion of bone. The Wassermann test was strongly positive.

A diagnosis was made of abdominal aneurysm, and on Oct. 6 Mr. Gask passed a No. 4 cage into it by means of Colt's apparatus. The skin was cleaned with ether and picric acid, and a longitudinal incision was made through the skin at the level of the tenth dorsal vertebra and to the left of the middle line. The patient died suddenly from rupture of the aneurysm at 12.30 p.m. on Oct. 15, nine days after the operation. He rallied well from the operation, and said that he had experienced much relief from the pain, which had previously been unbearable. The pulsation, however, remained unchanged and the femoral pulses were good.

Subsequent examination of the body showed a large aneurysm of the abdominal aorta arising just below the pleural reflection. The primary opening of the sac was at the level of the first lumbar vertebra in the posterior wall of the aorta. The sac had expanded upwards into both sides of the thorax, pushing aside the diaphragm and the parietal pleura, downwards on each side of the spine, and posteriorly amongst the deep muscles of the back on the left side. The greater part of the aneurysm lay in the left pleura, and it had burst through a ragged and bruised-looking opening just above the diaphragm. The sac had made its way amongst the deep muscles of the back and had eroded the last rib, which was fractured. Much of the sac contained laminated clot of old standing, but some more recent clot had formed round the strands of wire which had been introduced nine days before death. The cage of wire had expanded freely at both ends, but the recent clot did not extend to the ends of the wires which, during life, must have been bathed in fluid blood. There was no wire in the right half of the aneurysm where there was no clot. None of the wires were near the seat of rupture. The specimen is preserved in the museum of St. Bartholomew's Hospital, with the number 1551 F.

More or less pain is a constant feature of all pathological aneurysms. When it occurs quite early in the disease and in deeply-seated arteries the cause is often overlooked or misinterpreted. Here is an example which came under my notice a few years ago :—

Case 5.—A lady, age 46, complained of pain in the chest, loss of appetite, flatulence, discomfort after meals, and constipation. The pain was referred to the lower half of the sternum, going through to the left scapula. It was worse after food, and sometimes prevented her taking a deep breath. These symptoms were prominent throughout her illness, though they varied in intensity. She said that she had always suffered from a weak digestion, and to cure her 'dyspepsia' she was

in the habit of taking long walks—preferably uphill—and of bicycling. Her condition remained without material change from February, 1907, until August, 1910, during which time she took aspirin and bromides to relieve the pain. A physical examination of the chest in August, 1910, revealed a soft systolic murmur over the aortic valves, and at this time she was complaining of pain extending to the left shoulder and down the left arm. In January, 1911, pulsation was visible in the second left intercostal space near the sternum, and she had a cough with expectoration of mucus, which was occasionally blood-stained. The pain still continued, and was increased by the act of swallowing. A skiagram taken eighteen months later showed a sacculated aneurysm which contained a considerable quantity of clot and sprang from the descending portion of the arch of the aorta. The patient was then kept in bed; but in spite of rest, a low diet, and large doses of potassium iodide, the aneurysm increased in size, while the pain became more severe and was felt in the left axilla. Four months later the second, third, and fourth ribs on the left side, with the corresponding costochondral articulations, had become eroded. The aneurysm was wired on March 25, 1913, and she left the nursing home on April 19, twenty-five days after the operation, with pulsation in the aneurysm almost imperceptible and the pain greatly diminished. She lived until the aneurysm ruptured on July 26, the pulsation remaining imperceptible from April to July, and with only occasional attacks of pain which she said were quite bearable.

I was fortunate enough to obtain a post-mortem examination of the body, and the specimen is preserved in the museum of St. Bartholomew's Hospital (No. 1551E), with the following description :—

"A section through a large aneurysm of the third part of the arch of the aorta which had been treated four months previously by gilt wires inserted by means of a Colt's apparatus. The aneurysm springs from the left side of the descending aorta at its junction with the aortic arch; it has eroded the second, third, and fourth left ribs and costochondral joints, and passes through an aperture in the chest-wall fully 3 in. in diameter. The aneurysmal sac measures 5 in. in diameter, and is more than two-thirds filled with firm laminated clot, embedded in which is a network of gilt wires. The laminated clot is from $2\frac{1}{2}$ in. to 5 in. in thickness, and the double wisp, which has expanded freely, is embedded along its inner aspect."

It is clear, therefore, that the bulk of the laminated clot has been formed since the introduction of the wisp, or the wires could not have expanded. Some of the free ends of the wires lie in recent clot. This recent clot is $\frac{3}{4}$ in. in thickness and is situated in that part of the sac lying outside the chest-wall. The rupture has taken place as a small slit which allowed the blood to pass into the left pleura. The aneurysm lying inside the chest is cured; that lying external to the chest-wall, and which is of the size of a man's fist, still remains.

This case well illustrates the character of the pain in aneurysm. It is slight and badly localized in the early stages, but it is constant and tends to get worse; in the later stages it often becomes so severe as to render the patient's life intolerable. The less the clotting in the sac, the greater appears to be the pain in the earlier stages of the disease. It may be caused, therefore, by the distention of the inflamed wall of the artery. If this be the case the good results following the wiring of an aneurysm are easily explained. A clot is formed round the wires, the pulsation is diminished, and the pain is lessened because the arterial wall is at rest.

The severe pain of the later stages is felt when the aneurysm is brought into relation with resisting structures which are either absorbed or inflamed by the intermittent pressure. It is usual, therefore, to have severe pain in thoracic aneurysms where the ribs and costal cartilages are being eroded, and in the descending aorta when the vertebral column is involved. I have seen it in subclavian, and less frequently in popliteal, aneurysms; but carotid aneurysms and aneurysms of the cœliac axis may attain a large size without much pain. Even in these, however, no rule can be laid down, as is shown by the following cases.

In February, 1912, Sir W. I. de C. Wheeler showed 2 cases of aneurysm in the cœliac-axis region.[1] Colt's instruments were used in both cases. A cage of 150 in. of gilded wire was introduced in the first case, and a wisp of 105 in. in the second. The prominent symptoms before operation were intense pain in the back, marked epigastric pulsation, and digestive disturbances. A systolic murmur could easily be heard over the tumour. Sir William Wheeler considered that the pain in the back, which was severe enough to require morphia before operation, was more likely due to stretching and heaving of the peritoneum of the posterior abdominal wall than to erosion of the vertebræ. He also wired a third case of abdominal aneurysm, introducing 150 in. of wire and performing a gastro-enterostomy at the same time. The patient shortly afterwards developed symptoms of intestinal obstruction, and on re-opening the abdomen a loop of jejunum was

found compressed between the tumour formed by the aneurysm and the stomach and abdominal wall. The obstruction was relieved, but the vomiting continued to a less extent, and the patient died in a week from rupture of the aneurysm at a point remote from where the wire was introduced. At the post-mortem examination the wisp of wire was found situated between the layers of laminated clot—formed before operation—and had not expanded to any extent. The aneurysm extended from just below the cœliac axis to the level of the inferior mesenteric artery. An opening about the size of a shilling was found between the anterior wall of the aorta and the sac of the aneurysm. This opening was almost occluded by a valvular arrangement of laminated clot within the sac.

Sir William Wheeler commented upon the intense pain in the back suffered by this and two other patients upon whom he had operated. There was no erosion of the vertebræ in this case, and Sir William Wheeler suggested that the pain in the back, which is so constant a feature of this form of aneurysm, might be due to the stretching plus the heaving of the posterior parietal peritoneum. Stretching alone would not necessarily account for the pain. In each of the three cases the pulsation and pain in the back were more violent for a few days after the operation than they had been previously, but they then improved rapidly and the pain completely disappeared.

Of the two cases which survived, one was shown five years later.[2] The man had worked hard and continuously at his original employment in Guinness's brewery. He was free from symptoms, but a pulsating swelling could still be felt in his abdomen. There was no bruit to be heard over it, and the pulsation was no longer expansile. It may be assumed, therefore, that the aneurysm is cured. Sir William Wheeler tells me (February, 1921) that the man is still alive and at work in his usual situation, and that it is now eleven years and a half since the aneurysm was wired.

In the second case[7] the patient was passed as sound for service in the Naval Reserve, and during the war acted as stoker on a patrol trawler. He died of leakage from a secondary dilatation of the aorta below the aneurysm 4 years and 8 months after the operation. The aneurysm itself was about the size of a full-term fœtal head, and was apparently completely consolidated. The wires had expanded evenly.

Lieut.-Colonel C. B. Lawson, R.A.M.C., wired an aneurysm as large as a Tangerine orange springing from the aorta between the cœliac axis and the superior mesenteric artery. The operation was performed on May 6, 1906, the man's age being 33. He died on Nov. 26, 1916, and was able to perform his duties in the interval. The earlier details of the case are recorded in the Proceedings of the Royal Society of Medicine.[5]

Mr. R. C. B. Maunsell, of Dublin, wired an abdominal aneurysm in a woman, age 30, who lived a year after the operation. She was then readmitted to hospital suffering from acute abdominal pain. Next day she died very rapidly with symptoms of internal hæmorrhage. No post-mortem examination could be obtained. Mr. Maunsell writes: "This woman never gave herself a chance of permanent cure, as she drank heavily. The abdominal tumour never disappeared, but after the operation it remained firm, and I could not satisfy myself that there was expansile pulsation."

The severe pain in the later stages of some forms of aneurysm, therefore, is due to the effect of the pulsatile swelling on rigid structures, and if the pulsation be stopped the pain is relieved.

The effect of wiring in relieving pain in cases of thoracic aneurysm is greater in thin-walled aneurysms than in those which already contain much clot, and the relief follows quickly upon the operation. The introduction of the wire results in extensive coagulation of the blood in the sac, the clot being of the 'passive' variety; that is to say, it is like ordinary blood-clot and is not laminated. A soft and elastic buffer is introduced, therefore, between the pulsating blood-stream and the inflamed and painful structures which have been previously pressed upon intermittently. Presently some of the clot becomes organized and the sac-wall becomes thickened, so that if the patient lives long enough, and the aneurysm is well sacculated, with only a small communication between it and the vessel from which it rises, an actual cure may take place. Unfortunately, however, it is only too often a cure of the aneurysm and not a cure of the patient. The inflammatory

processes in the artery which led originally to the formation of the aneurysm continue in other or neighbouring parts. Another aneurysm is formed, or rupture takes place and the patient dies. Still, a few cures have resulted and many patients have been relieved of pain, so that the method is well worthy of more extended application, the more so as the operation is simple and is not attended with excessive danger. I do not see any advantage in combining electrolysis with wiring. It prolongs the operation, it introduces additional factors of danger, and it does not alter the physiological effect of the treatment, which is to obtain clotting within the sac. Admittedly the chief effect of it is to *initiate* the process of clotting, and this we now know is done quickly by the granular surface of the dull-gilt wisp. I have therefore never employed electrolysis, for it has always seemed to me to be reminiscent of a time when little was known of the physiological processes connected with the clotting of blood and too much was expected of electrical treatment.

DURATION OF AORTIC AND ABDOMINAL ANEURYSMS.

To enable an idea to be formed of the value of operation in cases of thoracic and abdominal aneurysm, Mr. Colt has investigated the notes of all the fatal cases which occurred in St. Bartholomew's Hospital during the thirty-six years 1871–1907 inclusive, and has included twenty-two cases given by Nunneley[4] and two by Sir William Osler.[5] In the 179 cases collected by Nixon[6] the duration of the disease is only mentioned in one case, and this is included in the present list. The numbers are those of patients whose records are sufficiently explicit to allow an estimate to be made of the length of time which intervened between the first complaint of symptoms and death—no operation having been performed. They are too small to warrant an average, and the median duration of the disease, therefore, has been taken instead. The Registrar-General is unfortunately unable to furnish any data compiled from death certificates. Such data in this and other diseases would be of great value in determining prognosis, and would aid the assessment of the value of operation in any particular case. The table of male cases is as follows :—

Site of Aneurysm	Median Age	Median Duration of Symptoms	Number of Cases Analyzed
Ascending arch	44	15 months (max. 4 years 4 months)*	34
Ascending and transverse arch ..	46	9 months (max. 1 year 9 months)	16
Transverse arch	39	7½ months (max. 3 years 1 month)	24
Transverse and descending arch..	Number of cases insufficient to generalize		
Descending arch	49	15 months (max. 3 years 3 months)	11
Descending aorta	39	10½ months (max. 6 years)	6
Abdominal aorta	36	10 months (max. 3½ years)	42

* An exceptional case in which the disease lasted at least eight years has been omitted.

Aneurysm is much less common in women than in men. Of five cases in which the *ascending* portion of the arch of the aorta was affected, the mean age was 42½ years ; the mean duration was 25 months, the maximum being 54 months. In three cases where the *transverse* portion of the arch was involved, the mean duration was 21 months and the average age 46 years. The longer duration of symptoms in women suffering from aneurysm of the transverse part of the arch may, of course, be due to the small number of the cases, but as the pressure symptoms are greatly aggravated when consolidation occurs in this portion of the arch, operation is clearly out of the question.

I have purposely headed this paper, "The Palliative Treatment of Aneurysm by Wiring," because I do not wish to raise vain hopes about the treatment of a deadly disease. I know quite well that relief from pain is often secured by rest in bed for a prolonged period of time on a low diet with restriction of fluids and the administration of large doses of iodide of potassium. In the cases which have been given in this article, these methods had been tried by competent persons under the best possible conditions of nursing, and had failed. In nearly all the cases the pain was relieved by wiring, and two of the patients returned voluntarily and asked for a second operation. In some of the recorded cases an actual cure of the aneurysm seems to have followed the introduction of the wire, but in spite of the figures which Mr. Colt has been good enough to supply, we do not yet know enough about the natural history of the disease to say whether this great prolongation of life was in consequence of the operation or whether it would have occurred spontaneously. This will form the subject of a future investigation.

The following is a summary of all cases up to March, 1921, treated by Colt's apparatus, without electrolysis :—

1. Male.—Ascending arch ; right carotid and subclavian tied two years previously ; sac bulging externally. Died seven days after operation from external hæmorrhage.—*Unpublished.*
2. Female.—Descending arch. Died four months after operation from rupture of sac.—*Power.*
3. Male.—Ascending and transverse arch. Died eleven days after operation from dyspnœa.—*Power.*
4. Male.—Ascending arch. Died three and a half years after first and two and a quarter years after second operation, probably from rupture of sac.—*Power.*
5. Female.—Ascending arch. Alive and well two years after first and eight months after second operation.—*Power.*
6. Male.—Abdominal. Died two days after operation from ether pneumonia.—*Holt.*
7. Male.—Abdominal. Died four days after operation from rupture of sac.—*Power.*
8. Male.—Abdominal. Died two months after operation from leakage of sac.—*Unpublished.*
9. Male.—Abdominal. Died of pneumonia some months after operation. No further particulars could be obtained.—*Prof. Conway Dwyer.*
10. Male.—Abdominal (partly dissecting). Died six days after operation. The cage had not expanded.—*Braine Hartnell and Collins.*
11. Male.—Abdominal, causing pyloric obstruction ; gastro-enterostomy. Died of rupture of sac seven days after wiring.—*Wheeler.*
12. Male.—Abdominal. Alive and well eleven and a half years after operation.—*Wheeler.*
13. Male.—Abdominal. Died four years eight months after operation from leakage of secondary dilatation. Aneurysm apparently cured.—*Wheeler.*
14. Male.—Abdominal. Died nine days after operation from rupture of sac.—*Gask.*
15. Male.—Abdominal. Died ten and a half years after operation. No details ascertained.—*Lawson.*
16. Female.—Abdominal. Died one year after operation, probably from rupture of sac.—*Maunsell.*

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[2] *Trans. Roy. Acad. Med. Ireland*, 1916, xxxiv, 266.
[3] Lt.-Col. C. B. Lawson, *Proc. Roy. Soc. Med.* (Surg. Sect,), 1913, v, part 3, 178.
[4] F. P. Nunneley, *Aneurysm of the Abdominal Aorta.* London : Baillière, Tindall & Cox.
[5] Sir William Osler, "Aneurysm of the Abdominal Aorta ", *Lancet*, 1905, ii, 1089.
[6] J. A. Nixon, *St. Bart.'s Hosp. Rep.*, 1911, xlvii, 43.
[7] *Brit. Med. Jour.*, 1911, Oct. 28, and *Lancet*, 1917, April 7.

OBSERVATIONS ON FIFTY CASES OF HOUR-GLASS STOMACH SUBJECTED TO OPERATION.*

By W. THELWALL THOMAS, Liverpool.

In studying the notes of fifty consecutive cases of hour-glass deformity of the stomach (bilocular stomach) surgically dealt with, many points of interest seem worthy of record.

1. **Sex Incidence.**—The rarity in the male—only 4 cases occurring in men, 46 in women.

2. **Symptoms.**—In 8 cases a long history of gastric pain; in 28 cases a long history of pain and vomiting; in 14 cases a long history of pain, vomiting, and hæmatemesis—only in 3 cases, however, was the bleeding at all severe; but one had suffered from five attacks of gastric hæmorrhage, while in the others merely a trace of blood had appeared on rare occasions. Four had been operated upon for perforated gastric ulcer.

The most noticeable feature was the long duration of symptoms before surgical aid had been resorted to—with the exception of 3 patients, whose symptoms had only lasted one, two, and three years respectively. All the others had complained of gastric trouble for periods varying from five to thirty years; taking an average, it worked out at nine years, and most of the sufferers had been under medical treatment intermittently throughout.

3. In no single patient had malignant disease supervened, which, although suspected in two cases, was disproved on operation.

4. It had not been possible in a single case definitely to diagnose bilocular stomach by ordinary methods, radiography being essential.

5. Two cases (in addition to the 4 perforated ulcers) had been previously operated upon—1 by gastroplasty and 1 by posterior gastro-enterostomy—though another one had had the gall-bladder drained (no stone found), the symptoms having suggested biliary colic.

From this series of cases it appears that the acute-hæmorrhage variety of gastric ulcer rarely leads to this deformity—but rather the chronic ulcer on the lesser curve with many years' history of a continuous or intermittent type. Many ulcers had completely healed, leaving a hard scar which in process of years had drawn to itself the adjacent areas of gastric wall so as to produce the contraction. Many had unhealed ulcers—some with extensive adhesions to liver, pancreas, and even to the anterior abdominal wall—while others had a fold of great omentum caught up to the lesser curvature, suggestive of old partial perforation. In view of the current opinion that malignant disease of the stomach is grafted on a chronic ulcer foundation, this series of fifty without a single malignant case does not support it, although the symptoms had lasted twenty and even thirty years in some of the patients.

Radiographic examination is essential to elucidate the condition, all other methods having failed; and the valuable reports in each of the cases by my friend and colleague, Mr. Thurstan Holland, revealed many important points. His reports and photographs in seven of the cases demonstrated pyloric stenosis in addition. His observations on the activity or otherwise of the muscular walls, and the relative sizes of the two sacs, were of great value. It was noticeable, however, probably owing to the weight of the barium meal in the lower pouch, that the area of constriction seemed to be much longer than that

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* Read before the Manchester Medical Society.

found subsequently on operation, with the stomach washed out and the patient, of course, lying down; and this drag, or prolapse, rather tended to mislead as to the position of the upper sac. This must be realized, and great care taken to explore thoroughly as far as the actual cardiac orifice. Gastro-enterostomy has been performed on the wrong pouch owing to this neglect.

It cannot be too strongly emphasized that the only accurate means of diagnosis is by radiographic examination and report thereon by an expert, lest spasmodic contractions, which are very common, should be mistaken for the cicatricial variety. If this means of investigation had been resorted to many years earlier in most of my cases, the patients would have been relieved of much suffering, by resorting to surgical means earlier; for many of them were very emaciated, some to an extreme degree, suggesting malignant disease to their friends and medical attendants.

Surgical intervention is the only possible means of cure, and there is no condition in surgery that may call for so great a variety of procedures to deal with the degrees and complications met with; and although the radiographic evidence affords valuable help, it is impossible in any given case to have the slightest idea beforehand what surgical manœuvre will be resorted to.

The whole stomach, from the cardiac orifice to the pylorus, front and back, must be carefully examined, and the merits and possibilities of all known (and even unknown) described operations quickly considered, before deciding what course to pursue.

It is highly important in many of these semi-starved patients to use every known means to increase resistance and prevent shock. Rectal salines with glucose for a day or two before operation, subcutaneous salines, Crile's local anæsthesia, and open ether during operation on a well-warmed table will, with care and well-studied rapidity, bring many a patient through an anxious, bad surgical risk.

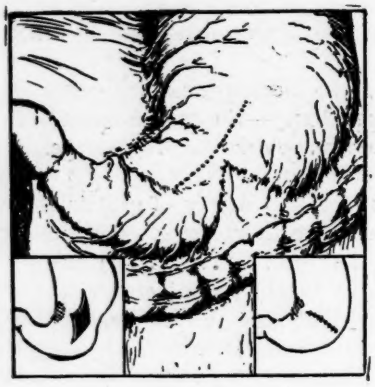

FIG. 30.

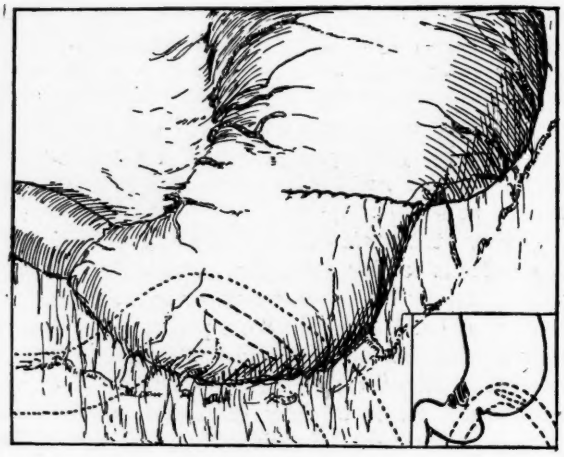

FIG. 31.

In this series the following procedures have been carried out :—

1. When the pouches have been large, with a fairly wide waist between, with much active muscular wall, gastroplasty was chosen in 6 cases—also in a seventh, but combined with a posterior gastro-enterostomy to the distal pouch on account of pyloric cicatrization (*Figs.* 30 and 31).

2. When the pouches were large, the constriction narrow and fibrous, and in several with extensive adhesions to the liver, gastro-gastrostomy proved satisfactory in 15 cases (*Fig.* 32).

3. Posterior gastro-enterostomy performed on the proximal pouch suggested itself in 14 cases—in 2 of these the union was made opposite the ulceration but extending well into both pouches, when the proximal sac was small and high up (*Fig.* 31, inset).

4. Where the pouches were about equal in size and the constriction extensive, with pyloric stenosis in addition, double posterior gastro-enterostomy was resorted to in 2 cases (*Fig.* 33).

5. In 3 cases complicated by extensive adhesions in the lesser sac of the peritoneum to the pancreas, a retrocolic anterior gastro-enterostomy was possible (*Fig.* 34).

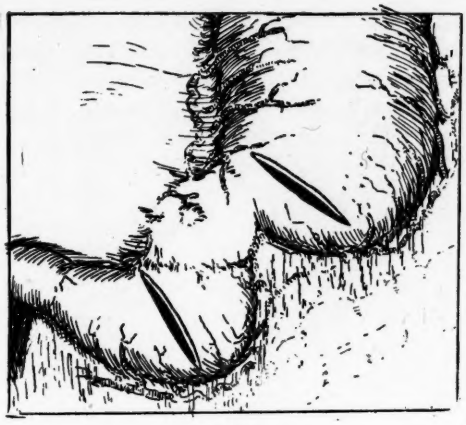

FIG 32.

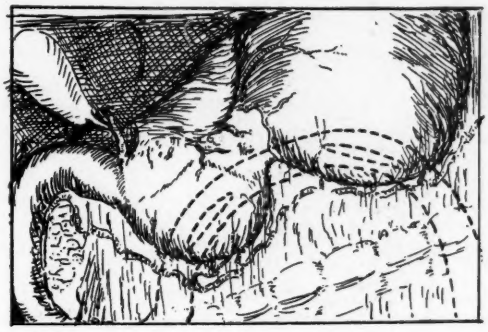

FIG. 33.

6. In 3 of the patients, each having a very small proximal pouch, with the lesser curve adherent to the liver, an anterior gastro-enterostomy seemed essential: and in one of these, the intestinal loop being long, an entero-enterostomy was added (*Fig.* 35).

7. In one very difficult recent case an extensive area at the constriction was adherent to the anterior abdominal wall at the level of the umbilicus, the stomach being much proptosed and acutely kinked, leaving only a small piece of available stomach in the front of the proximal pouch. It seemed inadvisable to separate the stomach from the abdominal wall, it being almost certain that if this were attempted the stomach would be extensively

FIG. 34.

FIG. 35.

opened and thus increase our difficulties and the risk to a patient extremely ill and emaciated. We were able to mobilize the second part of the duodenum, and perform a gastroduodenostomy between the proximal pouch and the duodenum *above* the area adherent to the abdominal wall (*Fig.* 36).

8. In another complicated condition, the lesser curve was intimately incorporated with the liver, the proximal pouch small and adherent posteriorly, while the front of the distal sac had hardly any portion not adherent to the liver; pyloric stenosis was present in addition. This looked for the moment an impossible problem to solve; but thanks to a retrocolic anterior gastro-enterostomy to the proximal, and a posterior gastro-enterostomy to the distal, pouch, we were carried safely through (*Fig.* 37).

9. The last two cases of the series necessitated partial gastrectomy :—

a. The constriction was excised, the distal part of the stomach closed, and the small intestine sutured to the end of the proximal pouch, the bowel loop being brought through the mesocolon (*Figs.* 38, 39).

b. In this case a very large distal pouch hung in the pelvis, the constricting ring being narrow (although the radiograph showed it some inches long). There were pyloric stenosis and some thickenings in the distal pouch suggestive of ulcerations. The lower

FIG. 36.

FIG. 37.

pouch was removed along with the constriction, and the proximal pouch dealt with as in the previous case. The specimen removed exhibited six ulcers.

I know of no condition that can provide the surgeon with such an intricate and interesting problem as an hour-glass stomach, and its solution is only possible after opening the abdomen. In spite of all our efforts to improve the condition of the patient before operation, and the care taken on the operating table to avoid shock, 7 deaths are to be recorded in this series, namely : 3 following posterior gastro-enterostomy (two women, one man) ; 2 following gastro-gastrostomy (one three weeks later from pneumonia

FIG. 38.

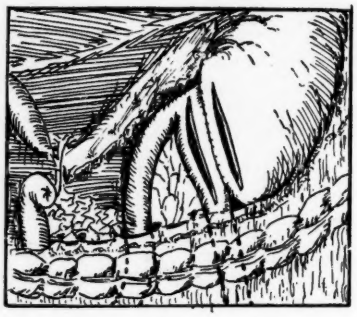

FIG. 39.

and empyema) ; 1 following retrocolic anterior gastro-enterostomy in a male ; and 1 following partial gastrectomy, also in a male.

Three of the patients succumbed to bronchopneumonia in a few days, and one died suddenly from pulmonary embolism on the fourteenth day. One gastrectomy case died suddenly next day, and two others simply from lack of recuperative power.

Ether was administered by the open method in all cases by a skilled anæsthetist.

The mortality-rate may appear high ; but what mostly impressed us was the astonishing recovery in a great many almost hopeless cases, in persons reduced to extreme emaciation through long years of suffering. It is hoped that, in future, much earlier resort will be made to radiographic investigation in vague cases of chronic indigestion that do not readily yield to medicinal and dietetic treatment.

With such a variety of operations necessary to deal with this condition, it was interesting to ascertain the end-result to the patient. Mr. R. Kennon kindly undertook this for me, and through his assiduity I am able to report on all but three of the cases. It does not appear that any particular type of operation had much to do with the final result, provided a free flow had been established from the stomach.

Only 6 have complained of gastric symptoms since operation; 1 operated upon five years ago has 'some vomiting'; 1 operated upon three years complains of 'vomiting'; 2 have some indigestion; 1 had a severe attack of hæmatemesis one year after operation, and was subsequently radiographed, but she has now been well for four years. Four have died from diseases unconnected with stomach trouble.

All the others send expressions of thanks and gratitude, and the most frequent answers have been, 'eat anything', 'quite well', 'very good health', and one who had suffered severe pain for many years alludes to the operation as 'a miracle'.

A CASE OF HOUR-GLASS STOMACH.

By G. A. EWART, London.

The following case seems to be worthy of record from the fact that it is a good example of a somewhat rare condition, and also has the added interest of extending over a period of more than twenty years, being almost historical in a surgical sense. Further, it perhaps throws some light on the treatment of conditions with which the abdominal surgeon is sometimes confronted.

In the year 1897 the patient, then a girl, age 22, was subject to attacks of severe abdominal pain, indigestion, vomiting, and hæmatemesis. These symptoms may be said to have reached a climax in 1900, when the patient was seized with acute abdominal pain, and the diagnosis of perforation of a gastric ulcer was made. This occurred in Egypt, and though no surgical measures were adopted, the patient made a slow recovery. She returned to this country, and towards the end of 1900, as pain and vomiting persisted, she was seen by Sir Arthur Mayo Robson, who, after investigation, made the diagnosis of hour-glass stomach. In November, 1900, an operation was performed in Leeds Infirmary, and a posterior gastrojejunostomy was done to the proximal pouch of the stomach with the aid of the operator's bobbin. An account of the operation may be found in *Diseases of the Stomach and their Surgical Treatment*, by Mayo Robson and Moynihan, and may be quoted.

> "Miss D. B., age 25, was admitted to the General Infirmary, Nov. 5, 1900, with a history of stomach symptoms for three years, with pain and vomiting. During part of the time, she had been in hospital and under thorough medical treatment, but without material benefit, except of a temporary character.
>
> "Operation, Nov. 15, 1900.—A large constriction was found in the centre of the stomach, forming a characteristic example of hour-glass contraction, both cavities being dilated, the proximal being larger than the distal cavity. Numerous adhesions had to be separated, especially around the pylorus, and others between the stomach and colon. A posterior gastro-enterostomy was performed, from which the patient made an uninterrupted recovery: she returned home on Dec. 11. On April 9, 1901, she returned to the Infirmary, having had some recurrence of pain and vomiting; but under rest and careful dieting the symptoms completely passed off in three weeks, and she was sent home weighing 7 lb. more than she did when in hospital on the former occasion. During the three weeks the patient was under observation she had no sickness, and during the latter part of the time was able to take ordinary food without discomfort."

This improvement was maintained for some time, but gradually the patient's condition became worse, pain without vomiting being chiefly complained of, until, in the year 1913, the appendix was removed by another surgeon, as it was supposed to be responsible for a certain degree of mucous colitis which was present. No improvement of the condition followed this operation.

The above gives a summary of the case until the time when I first saw the patient at the end of 1920. Previous to this the patient had been in hospital for some two months, under strict medical treatment, without deriving any marked benefit, the chief complaint being of pain, even after fluid diet; the pain was localized to a spot situated about midway between the ensiform and the umbilicus. Vomiting was only occasional. Some six months previously there had been slight hæmatemesis. On examination the patient was noticed to be rather wasted; firmly healed scars were present in the appendix region and over the right upper rectus segment. On palpation of the abdomen some tenderness without rigidity was noted in the epigastric region, but no mass could be felt. Investigations

were next made by means of a bismuth meal and *x* rays. *Fig.* 40 shows what was found; that is, an hour-glass stomach with a large proximal and a small distal pouch about the size of a golf-ball, with a very attenuated passage leading from one to the other. It may be further noted in the picture, which was taken fifteen minutes after the meal, that already a small quantity of the bismuth shows in the upper coils of the jejunum, proving that there was no marked pyloric stenosis. Further *x*-ray examination showed that there was very marked delay in the complete emptying of the proximal stomach pouch. No sign whatever could be seen of the functioning of the previously performed gastrojejunostomy.

Under these conditions, a further laparotomy was decided upon. The abdomen was

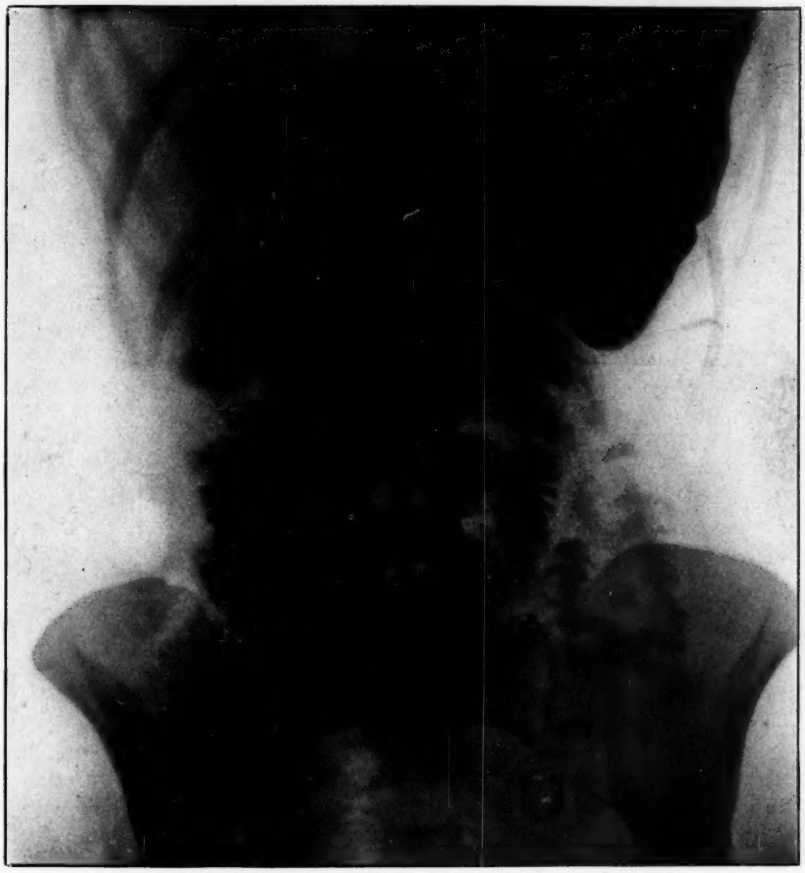

FIG. 40.—Skiagram showing the condition before operation.

opened through the left upper rectus segment on Jan. 30, 1920. After dividing many adhesions, it was found that the stomach was encircled by a dense fibrous ring more than an inch in breadth, some two inches proximal to the pylorus. This ring-like stricture was adherent posteriorly to the pancreas, and above to the under surface of the liver. The stricture was so dense that it was difficult to form an accurate opinion of the size of the passage between the two pouches of the stomach, but it was estimated to be about the size of a No. 10 catheter. On examination the pylorus showed no signs of stenosis; there were, however, some surrounding adhesions to the under surface of the liver. On turning up the transverse colon, the jejunum was found to be adherent to the transverse mesocolon at the site of the previous gastrojejunostomy. Much matting of the intestines made the procedure difficult, but eventually the efferent loop of the jejunum was isolated. This

was traced up to the previous seat of the anastomosis, and the junction carefully palpated. No stoma between the stomach and the intestine could be felt. The next question was what was the best procedure to adopt. Obviously any anastomosis between the proximal and the distal pouches of the stomach (gastrogastrostomy) was out of the question, the distal pouch being too small to allow of any satisfactory channel being established. Gastroplasty, on account of the breadth and density of the stricture, was also impossible. One alternative was to undo the old gastrojejunostomy, and re-establish the opening in the site of the previous anastomosis. This would have been very difficult to accomplish on account of the dense adhesions and almost complete obliteration of the lesser sac of peritoneum.

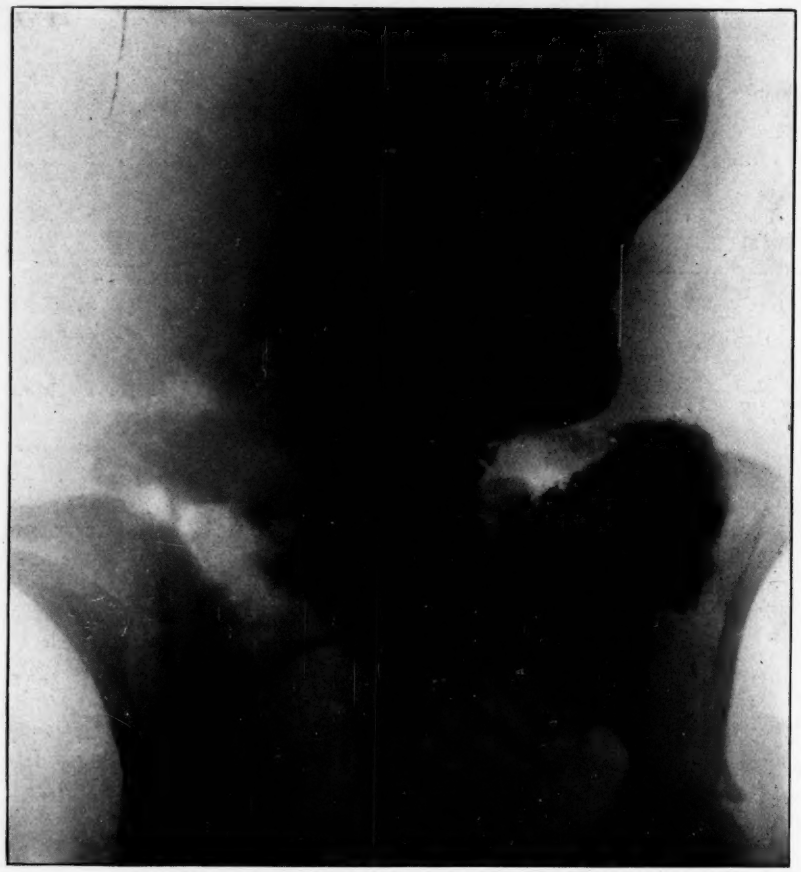

FIG. 41.—Skiagram taken in the erect position during expiration ten minutes after a bismuth meal.

The only other alternative seemed to be to do some form of anterior gastrojejunostomy to the proximal pouch. On consultation with my colleague, Sir Crisp English, who happened to be watching the operation, I determined to do an anterior retrocolic gastrojejunostomy, as first carried out by Mr. Sherren (Choyce's *System of Surgery*, vol. ii). This seemed a better plan than bringing the jejunum across the transverse colon, which involved the risk that the transverse colon might be caught up in the adhesions which had been divided, and perhaps cause trouble at a later date. An opening was therefore made through the transverse mesocolon just to the right of the old anastomosis. Through this opening, the jejunum was brought into the lesser sac, and then, by incising the gastrocolic omentum, the coil of gut was brought forward to the anterior aspect of the proximal pouch of the stomach. Here a gastrojejunostomy was performed after the usual manner,

silk sutures being used throughout. Care was taken to keep the new stoma as near the stricture as possible, to prevent any S-shaped kinking of the gut between its two fixed points. After the completion of the anastomosis, the jejunum was opened just beyond the new stoma to investigate better the lie of the gut, and incidentally the seat of the previous operation. It was found that the new opening was about two inches in length; from this point the finger passed backwards and somewhat to the left, and came to the seat of the old opening, without any intervening loop. No sign of the original stoma between the stomach and jejunum remained, some scar tissue alone indicating its position. The opening made in the jejunum for this investigation was next closed with two layers of continuous silk suture. First changing gloves and instruments, the abdomen was closed in layers. After the operation, a fear was entertained that the kinking entailed by bringing the jejunum from the posterior to the anterior aspect of the stomach might prove prejudicial. These fears, however, proved groundless, and the patient made an uninterrupted recovery. She was seen just a year after the operation, when the second radiograph (*Fig.* 41) was taken. This shows a bismuth meal ten minutes after ingestion, the patient being in the erect position. The large proximal and small distal pouches of the hour-glass stomach can still be seen, the distal pouch being, if anything, a little contracted. The functioning of the new anterior retrocolic gastrojejunostomy shows extremely well, a large quantity of the opaque meal having already passed through the stoma at the short interval of ten minutes after ingestion.

With regard to the patient, she can hardly be recognized as the same individual. Since operation she has lost all her pain, and is now able to tolerate ordinary diet without discomfort. During the past year she has increased 22 lb. in weight, almost 2 lb. a month, and is now able to carry on her occupation. All pain and tendency to 'colitis' have been lost, and, generally, the condition of well-being of the patient may be summarized in her statement that she "does not know herself". The question arises as to whether this improvement is likely to be permanent. Personally, I think there is little possibility of the new stoma closing, the degree of stenosis between the two pouches being such that it must be much easier for food to pass along the new channel than find its way painfully into the distal pouch of the stomach. Probably when the first operation was done the circular ulcer was not fully cicatrized, and the lumen between the two pouches was much larger.

The above case seems of interest, inasmuch as it gives an indication as to the line of treatment in cases where a gastrojejunostomy, though still needed, has, for some reason, ceased to function. Any surgeon who has had either to undo, or re-fashion, a gastrojejunostomy, has doubtless been confronted with adhesions which have proved a great difficulty.

This case shows that a satisfactory result can be obtained by an anterior retrocolic gastrojejunostomy, even though the jejunum proximal to the anastomosis is anchored to the posterior aspect of the stomach, which necessitates a certain amount of angulation in bringing forward the intestine.

In conclusion, I should like to thank Mr. W. A. Coldwell for the radiographs which illustrate this case.

INTUSSUSCEPTION: A MONOGRAPH BASED ON 400 CASES.

By W. S. PERRIN, London; and E. C. LINDSAY, London.

The material for this investigation has been collected from the London Hospital records of the cases of acute intussusception admitted during the eighteen years from 1903 to 1920 inclusive. Only the first seven cases admitted during 1920 have been included, in order to bring the total number up to a level 400. Otherwise, with few exceptions, every case admitted during the eighteen years surveyed has found a place among the 400.

It is obvious, in compiling statistics with reference to any one point, that information will not always be forthcoming from each of the 400. Thus, while in every one of the cases it has been possible to ascertain the age of the patient and the month of the year in which he or she was admitted, in only 341 is the type of intussusception described. On the whole, however, fairly full data have been available in almost every instance. Thus, in the majority of the notes the length of the history is given, and by searching the records of the operating theatres it has been possible to ascertain the time occupied by each surgeon in performing the operation, while in many cases which have died, reports of the post-mortems have been available and have yielded valuable information. The series is a consecutive one, though a few cases have been excluded on account of the poverty of the notes, and the operating-theatre registers reveal the existence of several cases the notes of which cannot be traced.

There are records also of 19 cases of intussusception during the eighteen years surveyed which we considered either to come under the heading of the chronic variety of intussusception or to have too doubtful a history to be definitely included among the acute. They have therefore been excluded from the series, which deals with the acute form only.

In theory it is difficult to define exactly the dividing line between an acute and a chronic intussusception, but in practice the two varieties are rather sharply distinguished from each other. For example, the longest history in our series of acute intussusceptions is ten days. The patient was a youth, age 20, and at operation the gut was gangrenous. This is a fairly long history for an acute intussusception, and is to be accounted for by the age of the patient, for in small children an acute intussusception seems to take about six or seven days to kill, if it persists and is untreated: in several cases it is recorded that the patient was moribund on admission after a typical history of six days' duration. The shortest history in the series of chronic cases, on the other hand, was three weeks; the gut was not gangrenous and the symptoms had not been severe.

The series as it stands consists therefore of 400 cases, and does not fall far short of the total number dealt with by the hospital during the eighteen years included in the period 1903–20. This series, as far as we know, is the largest consecutive series yet investigated. Leichtenstern[1] collected 593 cases, but these were drawn largely from the literature of the subject. Since it is chiefly unusual cases that find their way into the literature, it is clear that deductions drawn from a collection such as Leichtenstern's are liable to many fallacies. An excellent example is afforded by his statement that 42 per cent of all intussusceptions undergo spontaneous elimination; while our series does not

provide a single example of spontaneous elimination. While it is only fair to point out that Leichtenstern's paper was published in 1873, when laparotomy was practically unknown, and thus opportunities were given for spontaneous elimination to occur which the present practice of early surgical intervention does not provide, still the figures he gives of the number of spontaneous eliminations could only have been obtained from records composed mainly of abnormal cases.

To a certain extent the same criticism applies to Fitzwilliams'[2] series of 1000 cases, including as it does cases published in the *Lancet* and the *British Medical Journal* for the seventeen years up to the date of writing the paper, viz., 1908, as well as cases drawn from other sources. It will be seen, however, that the statistical results obtained from Fitzwilliams' series are in substantial agreement with our own.

ETIOLOGY.

Sex.—There is a marked preponderance of males over females. The ratio is roughly 2·1 to 1·0, the numbers of each sex affected in the series being 272 males and 128 females, i.e., 64 per cent of all cases are males. This ratio is practically the same as that obtained by Fitzwilliams, who in 788 cases found 536, or 68 per cent, males. Adams'[3] series of 100 cases gives a similar number of males affected, viz., 66 per cent; Leichtenstern's series of 593, a ratio of 1·8 to 1·0.

Age.—*Fig.* 42 shows the age incidence in years. It is seen that the vast majority of cases occur during the first two years of life. Of the four hundred patients, 314 were under the age of two years, a percentage of 78·5, while 279 were under the age of one year, a percentage of 69·75. The chart illustrates the age incidence up to the fourteenth year only. There were 18 cases over the age of fourteen. These fell between the fifteenth and fifty-eighth year of life. The age of the youngest patient in the whole series was one day, of the oldest fifty-eight years. While in the case of the infant surgical intervention was unavailing, it is gratifying to record that at the other extreme of life an uninterrupted recovery of the patient rewarded the surgeon's efforts.

In a series of 648 cases under the age of twelve years, Fitzwilliams found 71·9 per cent occurred in children not more than twelve months of age.

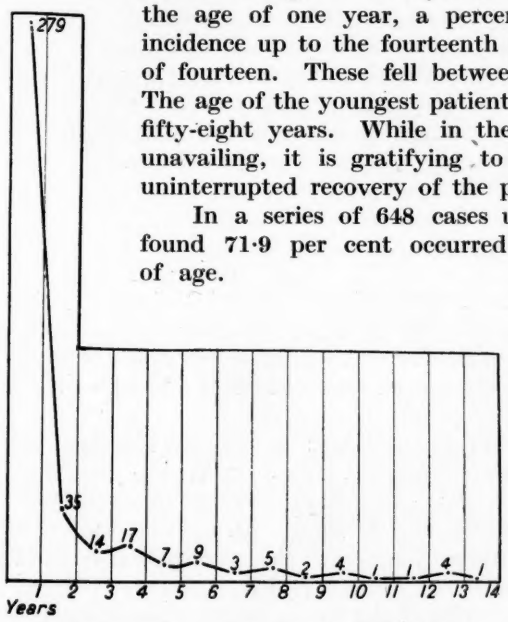

Fig. 42.—Curve illustrating age-incidence of acute intussusceptions in years. 382 cases are included in the curve, which ceases at the age of 14 years, for convenience of insertion; 18 other cases occurred between the ages of 14 and 58, making the total 400.

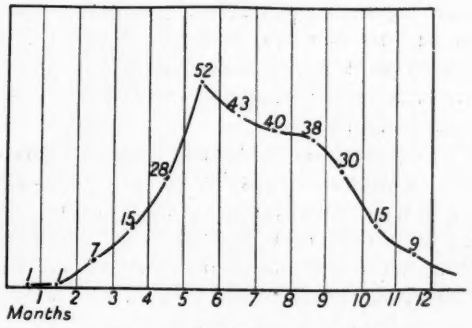

Fig. 43.—Graph of age-incidence of acute intussusception in months during first year.

That 78·5 per cent of all acute intussusceptions occur in children under two years suggests that some peculiar mechanism is in operation at this period. An analysis of the age incidence during the first year of life throws further light upon the question. *Fig.* 43 shows the number of cases occurring in infants during each month of the first year. It is seen that the curve rises steeply till five months of age, when the maximum is obtained. From this point there is a gradual fall till the age of nine months is reached, when the fall

is steeper. Of the 279 cases within the first year of life, no less than 203 (72·7 per cent) occur between five and nine months. Of all cases of acute intussusception of every kind, 203 out of 400 (rather more than 50 per cent) occur between the ages of five and nine months.

Fitzwilliams' curve, constructed from 458 cases occurring under twelve months of age, is similar to the above. His maximum occurs, however, at six months, and the curve rises from three months and falls from six to nine months much more sharply than our own.

That 50 per cent of all intussusceptions occur between the ages of five and nine months provokes the inquiry whether there is any constant change in growth or environment likely to be correlated with this peculiar incidence. Two such changes at least invite attention. From five to nine months is the period when teething with its associated gastro-intestinal disturbances commences, and at five months also the supply of the maternal milk is in many cases becoming inadequate to the needs of the growing child, and, as Fitzwilliams points out, breast feeding frequently begins to be supplemented by other foods. The possible bearing of this factor on the production of intussusception will be referred to later.

Season.—*Fig.* 44, describing the seasonal incidence, shows two maxima in the months of April and January. It further reveals the fact that 60 per cent of the cases occurred in the first six months of the year. The spring months of March, April, and May furnished 132 cases, while the autumn and early winter months of September, October,

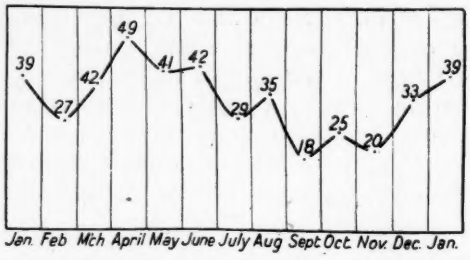

Fig. 44.—Curve illustrating seasonal incidence of acute intussusception.

No of cases in March to May	.. ..	132
„ „ September to November	..	63

and November furnished only 63. The disease is thus twice as prevalent in the spring as in the autumn, and has a second increased incidence about Christmas time. This agrees with Fitzwilliams' curve of 453 cases, with the curious difference that both his maxima occur a month earlier than our own, viz., March and December instead of April and January.

Relation of Intussusception to Seasonal Diarrhœa.—There is no relation between this disease and intussusception. The most cogent argument is that during the year 1911, when a severe epidemic occurred, no cases of intussusception were admitted to the hospital during the month of September when the epidemic was at its height. Again, investigation of the histories shows that in the 156 examples of ileocæcal intussusceptions only 11, and in the 126 ileocolic only 3, had a history of diarrhœa. A larger number of colic intussusceptions had a previous history of diarrhœa, 6 out of the 19 possessing histories lasting from three days to one week.

Relative Frequency of the Various Types.—The following *Table* gives the relative frequency of the various types. We think the figures are substantially accurate in spite of the difficulty of deciding at operation the precise variety dealt with. The numbers are fairly large and, upon the whole, as many cases of the ileocolic type will be wrongly described as ileocæcal as vice versa. Intussusceptions of other kinds are not likely to be confused with each other. It will be noted that in comparing our series with other observers' statistics, ileocæcal, caput-cæci, and ileocæcal-caput-cæci types are all lumped together as ileocæcal. The reasons for adopting this course are given in the discussion of the caput-cæci variety.

Table I.—Showing the Relative Frequency of the Different Types of Intussusception.

Variety	Males	Females	Both Sexes	Own Series		Leichtenstern		Fitzwilliams	
				Total	Per cent	Total	Per cent	Total	Per cent
Ileocæcal	73	40	113						
Caput-cæci	29	9	38	156	39·0	212	44		60·5
Ileocæcal and caput-cæci	3	2	5						
Ileocolic	90	36	126	126	31.5	39	8		25.6
Enteric	17	10	27	27	6·75	142	30		
Colic	12	7	19	19	4·7	86	18		7·3
Compound	2	2	4	4	1				6·6
Retrograde	1	1	2	2	0·5				
Meckel	4	1	5	5	1·2				
Unclassified	39	20	59	59	14·7				
Appendicular	1	0	1	1	0·2				
Jejunogastric	1	0	1	1	0·2				
			Totals	400	99·75	479	100	506	100

Including intussusceptions involving Meckel's diverticulum as enteric, placing the retrograde intussusceptions in their appropriate anatomical class, and assuming the same proportion of all classes of intussusceptions included in the group of 59 cases catalogued as unclassified, the percentages of different types in our series would still differ considerably from those of Leichtenstern and Fitzwilliams. This is found to be the case, for, excluding compound, appendicular, jejunogastric, and the unclassified group, and grouping the intussusceptions involving Meckel's diverticulum and the two retrograde cases among the enterics to which they belong, a net total of 335 cases is obtained, and the percentages then work out as follows :—

Table II.

Variety	Total	Per Cent	Leichtenstern per cent	Fitzwilliams per cent
Ileocæcal	156	46·5	44	60·8
Ileocolic	126	37·6	8	25·6*
Enteric	34	10·1	30	
Colic	19	5·6	18	7·3
Multiple and Double	—	—	—	6·1
Totals	335	99·8	100	99·8

* Includes also enterics.

If the 19 chronic cases are added to the series, the percentage of colic intussusceptions is slightly raised.

The numbers and percentages in the three series are then as shown in *Table III.*

Table III.

Variety	Own		Leichtenstern		Fitzwilliams	
	Total	Per cent	Total	Per cent	Total	Per cent
Ileocæcal	163	46·9	212	44		60·5
Ileocolic	128	36·8	39	8		
Enteric	36	8·3	142	30		25·6
Colic	27	7·7	86	18		7·3
Totals	354		479		506	

It is a little remarkable that our series should differ as much as it does from Fitzwilliams' in the relative frequency of the ileocæcal type. The terminology, however, is in such confusion that it is quite possible cases described as ileocolic in our series would be recognized as ileocæcal by other surgeons, and the discrepancy between our figures and Fitzwilliams' thus be accounted for. As we shall have occasion to point out, even with a clearly-defined terminology at our disposal, it is sometimes not easy to determine whether an intussusception arising in the neighbourhood of the ileocæcal valve is ileocæcal or not. In any case, accurate statistics of the relative frequency of the ileocæcal and ileocolic varieties will not be obtainable until a universally recognized classification is adopted.

The difference between our series and Leichtenstern's is easily accounted for. As Fitzwilliams justly observes, since Leichtenstern's paper of 1873 intussusception has probably been more frequently diagnosed in young infants, and thus the proportion of ileocæcal and ileocolic intussusceptions should be greater. This is strikingly borne out by examination of the 131 cases of intussusception collected by Waren Tay in 1873 and appended to Sir Jonathan Hutchinson's paper[4]. Of the total number of 131 cases only 62, and of the cases described as recovering only 6, were in children under one year of age.

TERMINOLOGY.

In the foregoing section the terminology we have adopted has been given with the reservation already expressed that we consider the caput-cæci and ileocæcal-caput-cæci varieties to be really ileocæcal. However, a short discussion of the various terms is necessary, because different authorities use the same words in somewhat different senses, and, as many different surgeons have operated on the 400 patients in our series, it is needful to make certain that the same terms are always used in the same way. We will therefore consider each of these in turn.

Ileocæcal.—The term ileocæcal was used by the older surgeons up to 1873 to describe any type of intussusception occurring in the region of the ileocæcal valve, and thus included many cases which would now be described as ileocolic. Since Leichtenstern's paper of 1873 the term has been restricted to the forms in which the ileocæcal valve itself heads the intussusception. It is in this sense exclusively that the word has been used by the London Hospital surgeons, for although on consulting the records of the ileocæcal cases we find that the vast majority are described simply as ileocæcal, in many specific cases mention is made that the ileocæcal valve formed the apex of the intussusception. In others, the ileocæcal valve and appendix are described as together forming the apex. Again, of other cases which reached the post-mortem room, in two ulceration of the ileocæcal valve is recorded; in another a lump at the ileocæcal valve is described; in a third, the ileocæcal valve is described as chronically thickened; and in all the valve is mentioned as constituting the apex. Further confirmatory evidence that the term ileocæcal has been properly used is furnished by the frequent mention in cases which died that the cæcum and appendix were 'gangrenous',

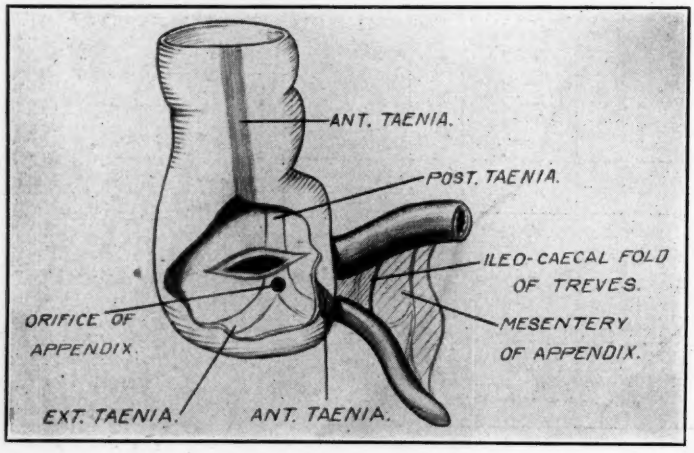

FIG. 45.

'easily broken through', 'much engorged', or 'much congested'; for it is on the appendix and cæcum that the main pressure falls in this type. This statement will be fully discussed in the section dealing with the caput-cæci variety. Lastly, in perusing the notes made on the ileocolic form, we find that intussusceptions originating as close to the ileocæcal valve as one inch are correctly described as ileocolic.

FIG. 46.—A, Longitudinal section of ileocæcal valve of child one year old. B, Longitudinal section of ileocæcal valve of child three months old.

Caput-cæci.—This variety was first described in detail by Sir Frederic Eve[5] in 1899 as the cæcal or caput-cæci variety, although mention is made by Lewis Smith, in 1862[6], of intussusceptions beginning in the caput cæci. It has been assumed that the inversion commences by the apex of the cæcum becoming invaginated, the ileocæcal valve and appendix being drawn in later. We agree with Barnard's view[7] that the inversion is only a "secondary and unimportant result of ileocæcal intussusception". The way this dimpling of the cæcum is produced is probably as follows: Reference to *Fig.* 45 of the cæcum and ascending colon will show that immediately below the ileocæcal valve lies the orifice of the appendix surrounded by the fused tæniæ of the ascending colon. At this point also the ileocæcal fold of Treves and the base of the mesentery of the appendix are attached to the ileocæcal junction. In addition, the lymphoid tissue is particularly thickly aggregated at this point (*Fig.* 46, B). Consequently, in the ileocæcal variety of intussusception the apex, though mainly formed by the ileocæcal valve, really also includes the base of the appendix. As these advance, the portion of the cæcum lying between the external and anterior tæniæ comes to form that layer of the apex of the intussusception which is in immediate apposition to the mass formed by the appendix, the root of the appendicular mesentery, the ileocæcal fold of Treves, and the associated lymphoid tissue of this area (*Fig.* 47). As Barnard points out, "the great cause of the obstruction of an intussusception

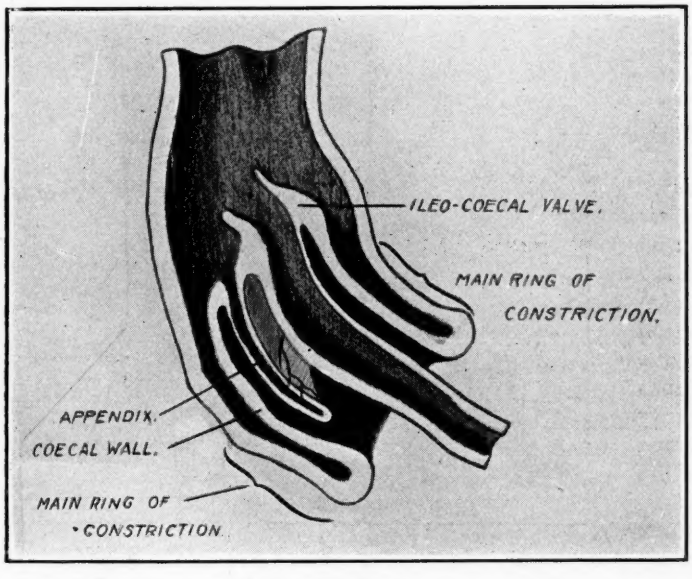

FIG. 47.

is the active and vital contraction of its sheath, and especially at its neck". The portion of the cæcum, therefore, which lies in immediate contact with the congested and swollen appendix will naturally share in the common œdema of the rest of the apex, and on reduction will present the characteristic dimpled appearance illustrated in *Fig.* 48.

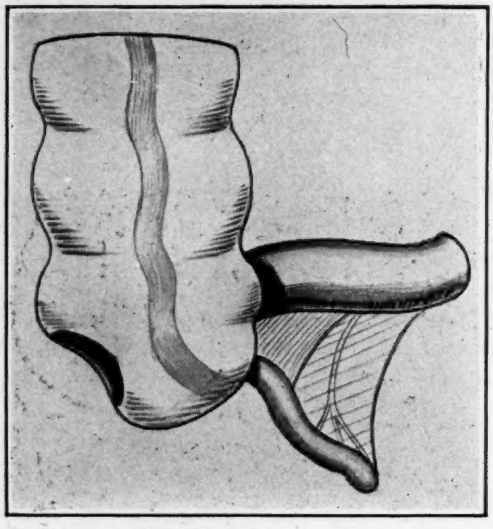

FIG. 48.

According to the amount of pressure exerted by the sheath on the neck of the intussusception, so will the dimple be more or less marked. It is to be anticipated that neither in very early nor in very late cases will the dimple be at its maximum. In the former, sufficient pressure will not have been exerted to cause such œdema, while in the latter the pressure will have produced gangrene and atrophy of the wall. It is a commonplace of surgical observation that a strangulated hernia of long duration presents an easily torn, thin, and flaccid wall. It is only in cases of medium duration that much œdema of a strangulated loop is present. The mortality of ileocæcal intussusceptions described as caput-cæci should therefore be less than that of those described as ileocæcal only: this is, in fact, the case. The percentage mortality of intussusception described in the series as ileocæcal is 35·9 per cent, that of intussusception described as caput-cæci is 23·3 per cent.

In most cases in which we ourselves have operated on an ileocæcal intussusception, this dimpling is more or less marked. In other words, every ileocæcal intussusception is also a caput-cæci in a more or less marked degree. It may be urged, why does not a similar dimpling of the wall of the cæcum take place in ileocolic intussusceptions, in which the apex is formed by a segment of the small intestine close to the ileocæcal valve which passes through the ileocæcal valve, moves down the colon, and drags the valve and cæcum after it? Where the apex of the ileocolic intussusception is formed by a section of the ileum very close to the valve —say within an inch—such a dimpling may occur, and undoubtedly does; but where the apex is formed some distance off, the explanation is that the wall of the cæcum no longer forms a portion of the apex of the intussusception, and in consequence does not become so œdematous. It is more likely to be flattened by continuous pressure of the ensheathing layer at the neck of the intussusception (*Fig.* 49).

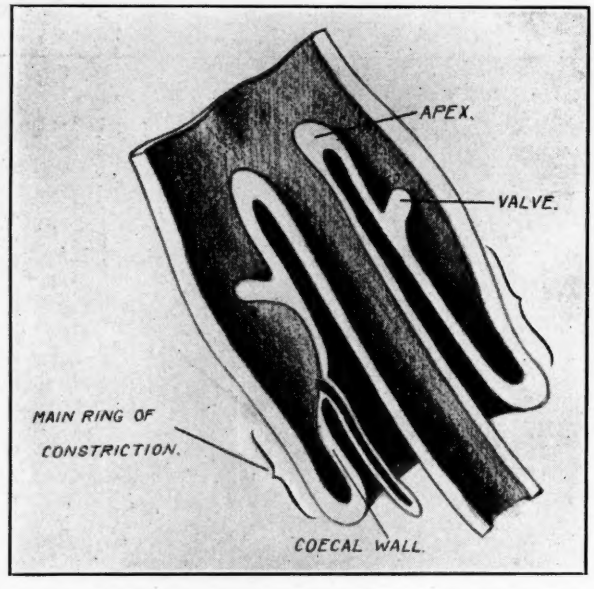

FIG. 49.

Both Fitzwilliams and Walton[8] agree that the caput-cæci variety is probably nearly

always a secondary result of an ileocæcal intussusception. Fitzwilliams lays stress, however, on a secondary slipping of the cæcal wall over the original apex formed by the ileocæcal valve, so that the dimpled portion of the cæcum represents a later-formed apex of the intussusception. We do not find ourselves in agreement with them on this point. The ileocæcal valve is, as *Fig.* 50 shows, a very large and prominent structure. It is not easy to see how the wall of the cæcum can slip down over the valve to produce a secondary apex, and such a slipping is entirely contrary to the otherwise universal method of growth of an intussusception, in which the original apex is the one fixed point. Again, if such an initial prolapse occurs, why should it not continue? Furthermore, we ourselves have not found, in reducing ileocæcal intussusceptions, that the last part of the intussusception to be reduced is the dimpled part of the cæcum.

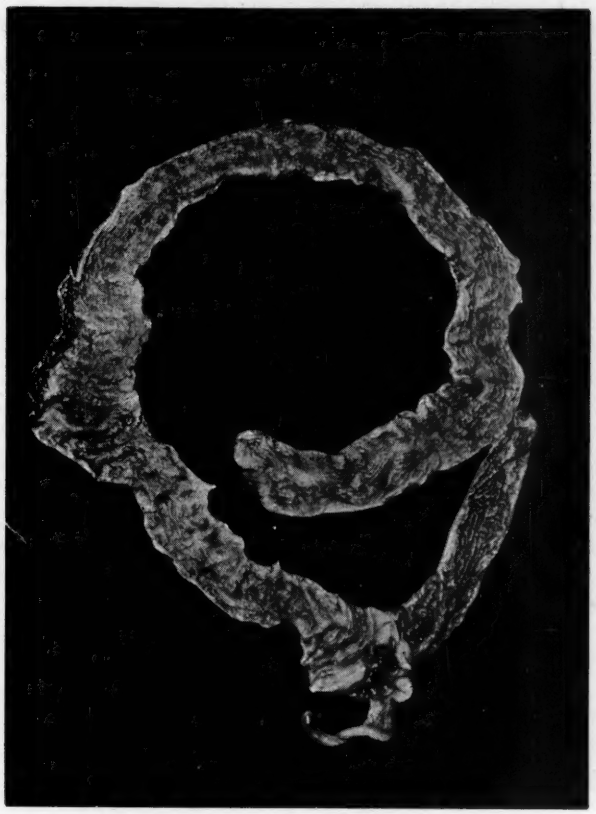

FIG. 50.—The ileocæcal valve.

Fitzwilliams, in common with other observers, points out that the orifice of the intussusceptum usually points towards the mesenteric side of the gut and away from the convexity of the intussusception, and adduces this as evidence of the slipping down of the returning layer of the intussusceptum opposite the attached mesenteric border. It seems more likely that this position of the orifice is due primarily to the traction of the mesentery, which produces the characteristic curve of an intussusception, and, secondarily, to the greater œdema of that lip of the apex which is opposite the mesenteric border of the intussusception; for, as Barnard points out, the œdema is always greatest along the convexity of the intussusception.

Ileocæcal and Caput-cæci.—It will be noted that 5 cases are designated 'ileocæcal and caput-cæci'. In other words, the surgeon was unable to decide to which type the intussusception belonged, and accordingly gave the double description. The description of these 5 cases gives additional evidence in favour of the view put forward above. In our opinion, use of the terms cæcocolic, caput-cæci, and ileocæcal-caput-cæci should be discontinued, and the term ileocæcal intussusception be applied to all intussusceptions taking their origin in the ileocæcal valve, which indeed always includes the base of the appendix, whether the dimpling of the cæcum, which has given rise to the creation of the unnecessary types variously called cæcocolic, caput-cæci, and ileocæcal-caput-cæci, be present or not.

Ileocolic.—From a close examination of the records, the term ileocolic has been uniformly applied to that type of intussusception in which an enteric intussusception close to the ileocæcal valve proceeds through the valve and drags the lips of the valve, the cæcum, and the appendix after, as part of the returning layer of the intussusception. *Figs.* 51, 52, 53, 54 illustrate the stages in the process.

The term ileocolic, however, has not been universally applied to this type of intussusception. At any rate, we can find no record in any earlier papers of the use of this

term, though from time to time accounts are given of intussusceptions consisting of a protrusion of ileum through the ileocæcal valve into the colon. In 1860, for example, Duchaussoy[9] in his monograph collected four cases. All these earlier writers, however, were content with recording the condition without giving it a name, an admirable example which has, alas, not been widely followed. The term was first employed by Leichtenstern in his monograph of 1873, in which he classifies intussusception into four groups, ileocæcal,

FIG. 51.

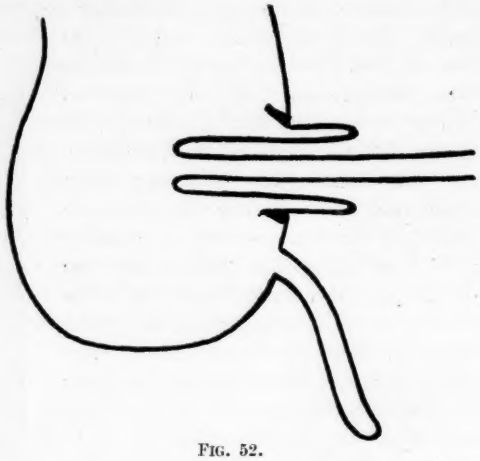

FIG. 52.

enteric, colic, and ileocolic, the last taking origin as an 'Einstülpung' of the ileum through the ileocæcal valve. Four years later, in his article in Ziemmsen's Cyclopædia,[10] he claims responsibility for the term ileocolic and again defines it in the following words: "Another form is that which I have named ileocolica. This kind of invagination represents a prolapse of the ileum through the ileocæcal opening. . . . . English literature contains several very close descriptions of ileocolon intussusceptions". He then proceeds to give

FIG. 53.

FIG. 54.

an account of the variety we have described above (*Figs.* 51–54) as forming the ileocolic of our records, and gives to it the name iliaca-ileocolica. He points out that at one stage of its progress an iliaca-ileocolica is indistinguishable from an ileocolic. This is the stage represented in *Fig.* 53. Sherren[11] has described an enteric intussusception in the act of passing through the ileocæcal valve, and expresses the view—with which we are entirely in accord—that the vast majority of ileocolic intussusceptions take origin in this way as

enteric intussusceptions. Walton has elaborated the same argument, viz., that an ileocolic intussusception is only a stage in the normal growth of an enteric as it passes down into the colon.

Examination of our records throws considerable light on this question, when the facts are considered in relation to the method of growth of ileocolic intussusception as defined by Leichtenstern. This method of growth is well described by Barnard as follows: "In simple ileocolic intussusceptions the ileocolic valve stands fast while more and more ileum is prolapsed through its orifice into the cæcum. . . . . Growth takes place entirely at the expense of the entering layer". It follows from this method of growth that Leichtenstern's ileocolic intussusception has no constant apex, it is constantly changing, and no swollen œdematous segment of gut is produced which can afterwards be identified as the apex. Furthermore, from the method of growth, reduction should be easy, nor can there ever be such pressure on the appendix or cæcum as to warrant resection. Now, in 16 per cent of our series of ileocolic intussusceptions the exact position of the apex is described, in another 6·2 per cent appendicectomy was performed, and in another 27·8 per cent either resection was performed or reduction was described as difficult. Thus, in 50 per cent of all the cases described in our series as ileocolic there is evidence that the condition originated as an enteric intussusception. It may certainly be argued that an intussusception may start as a prolapse of the ileum through the valve; that this may then cease, and the prolapsed segment form the apex of an intussusception growing in the normal way at the expense of its sheath. In view, however, of the thickness of the collar of lymphoid tissue which forms the terminal $\frac{3}{4}$ in. of the ileum up to the age of one year—and it must be remembered that 71·4 per cent of ileocolic intussusceptions occur during the first twelve months of life—such a prolapse does not seem likely. In any case, it seems a pity to erect a classification on a hypothetical method of growth for the existence of which evidence is very difficult to adduce.

Frequent mention is made in the literature of small degrees of prolapse in the mucous membrane of the ileum through the ileocæcal valve. The question arises in our minds whether the degree to which the ileocæcal valve projects into the colon in young children has been fully realized. If the origin of an ileocæcal intussusception is, as we believe, to be explained by an inflammatory œdema of the valve, the swollen valve might easily be interpreted as an evagination of mucous membrane, and thus prolapse of the ileal mucous membrane considered to be more common than is probably the case.

In spite of the fact that the term ileocolic by virtue of priority should be used to designate prolapse of the ileum through the valve, we are inclined to suggest that the term be used to denote any form of intussusception in which the ileum is found inside the colon, whether half-way through the valve, completely through, or with the ileocæcal valve dragged after it as a constituent of the returning layer. We exclude, of course, any form of double intussusception, which should be classified as compound.

A brief analysis of the 18 ileocolic cases in which the position of the apex is described may be of interest. In 2, the apex was eighteen inches above the valve; in 1, one foot above the valve; in 1, eight inches; and in the remaining 14, six inches or less. The majority, therefore, start quite close to the neighbourhood of the valve. It is clear that every ileocolic intussusception is primarily enteric. Among the enteric forms we have, however, included only those which have stopped short of the ileocæcal valve.

Enteric.—Of this variety 27 cases are recorded. The term requires no elucidation or special comment. However, it is noteworthy that some anatomical source of origin of the intussusception is more frequently mentioned in the notes on this variety than in any other, for in 6 of the 27 cases some such condition was recorded. In 2 a congenital constriction occurred, in 2 there was tuberculous ulceration of the gut, in 1 a polyp was present, and in another a myomatous tumour.

Compound.—This variety numbers 4 cases. The first occurred in a child age ten months and was a double colic intussusception. The apex was situated 2 in. distal to the cæcum, carried the cæcum with it, and then the whole was again intussuscepted. The

intussusception was reduced, but death ensued. The second was in a child of seven months. The last foot of the ileum was invaginated into itself and, pushing the ileocæcal valve in front of it, was invaginated *en bloc* into the colon. The third was a similar one in a child, age nine months. The apex was 9 in. from the ileocæcal valve, and the enteric intussusception thus formed pushed the ileocæcal valve in front of it and passed into the colon. The fourth and last began as an ileocolic intussusception and, when 9 in. of ileum had passed through the ileocæcal valve, the colon was invaginated into itself.

To certain of the above, specific names have been applied. In pursuit of simplicity of nomenclature we prefer to describe them all simply as compound. We are disposed to think that double intussusceptions are rather commoner than the series shows. In one case included among the ileocæcal variety the notes say that the intussusception was double for the last $1\frac{1}{2}$ in.

It is the practice in reducing intussusceptions to squeeze as much of the intussusceptum back as can be done inside the abdomen, and thus many double forms are likely to be missed. Double, triple, and quadruple forms of intussusceptions are, however, of academic interest only. The only difficult portion of an intussusception to reduce is the portion first formed; superadded invaginations are readily reduced with a little manipulation.

The above brief discussion of the terminology which has been employed, and consideration of the evidence provided by our own cases, show that reasons have been given in common with other writers for the abolition of the terms caput-cæci, cæcocolic, and ileocæcal-caput-cæci, as being only variants of the term ileocæcal. The 'simple' ileocolic of Leichtenstern, it has been suggested, should disappear on account of its rarity and doubtful existence, and be described as prolapse of the ileum; and the term iliaca-ileocolica likewise, the term of ileocolic taking its place.

We are thus in substantial agreement with the views expressed by Fitzwilliams in his admirable paper published in the *Lancet* in 1908. He states: "Up to quite recently the usual forms described were the enteric, the colic, the ileocæcal, and ileocolic. . . . This classification is the simplest and the most complete, and, with the exception of the name ileocolic, gives a correct idea as to the starting-point of each variety . . . . . but this simple classification has to its detriment been elaborated . . . . . until in a recent paper in the *Transactions of the Clinical Society* there was some hesitation expressed as to whether the correct name for a particular form of intussusception was entericileocolic, ileocæcal, or entericileocolicileocæcalcolic". To this simple classification of intussusceptions into four varieties we have added compound, appendicular, Meckel, jejunogastric, and retrograde. We think that the term 'compound' has its uses as including many rare intussusceptions for which a separate name must otherwise be invented, while the very rare intussusception taking origin in the inversion of the appendix must remain classified under a separate heading. Meckel, and jejunogastric intussusceptions, rare enough, are of course only special varieties of enteric intussusceptions, and obviously all retrograde intussusceptions are classifiable under one of the above four headings. There is something to be said for keeping these last five varieties, viz., compound, appendicular, Meckel, jejunogastric, and retrograde, as separate classes, for the terms are self-explanatory, and the examples are so rare that it does not materially affect any statistics of the four chief types whether they are included among the particular number of these four to which they belong or not.

The aim of all nomenclature should be to make description easier, and this the above method of classification attains, for we have only one, the 'ileocolic', which is not self-explanatory, and that is employed to designate one of the most common types of intussusception which could not be conveniently described otherwise than by some such artificial name. We are much opposed to designating every possible variety of intussusception by some separate name. If this be done the list becomes almost endless and serves no useful purpose; for example, within the limits of one single and otherwise admirable paper (we offer our humble apologies for the criticism) no less than eighteen different terms, many very complicated, are proposed to define different types of intussusception.

CAUSATION OF INTUSSUSCEPTION.

As a preliminary to discussing the causation or mechanism of the production of intussusception the attention of the reader is invited to the curves in *Figs.* 55–58, illustrating the age-incidence of the various types of intussusception. The curves show the age-incidence in the first few years of life only. The sporadic cases which are scattered throughout the remaining years of existence are appended in the form of a list, as their inclusion would make the curve too lengthy to be conveniently inserted. It will be noted that to each curve a list is attached of the chronic cases of each type which have come under our notice but otherwise have not been included in our list of 400 acute

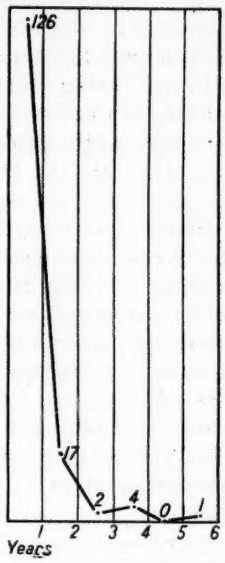

Fig. 55. — Graph showing age-incidence of acute ileocæcal intussusceptions. Six other cases occurred at age 9, 11, 27, 41, 44, 56. Seven chronic ileocæcal intussusceptions occurred at age 2, 5, 8, 40, 50, 63 (carcinoma of valve), 64.

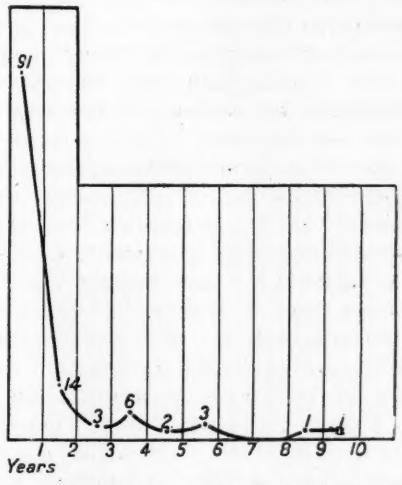

Fig. 56.—Graph showing age-incidence of acute ileocolic intussusceptions. Five other cases occurred at age 20 (two), 30, 32, 40. Two chronic ileocolic intussusceptions occurred at age 59 and 68 (button carcinoma as apex.)

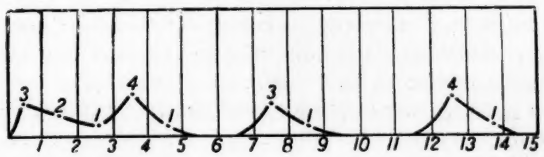

Fig. 57.—Graph showing age-incidence of acute enteric intussusceptions. Seven other cases occurred at age 19, 32 (apex a myoma), 34 (tuberculous ulceration of gut), 43 (two), 44, and 58. Two chronic enteric intussusceptions occurred at age 2 and 16.

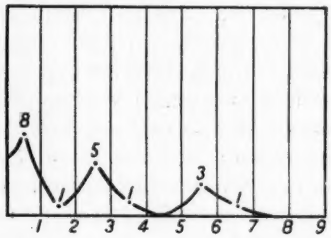

Fig. 58.—Graph showing age-incidence of acute colic intussusceptions. Eight chronic intussusceptions occurred at age 29 (two: myoma and carcinoma as apices), 43 (adenoma), 44 (carc.), 48 (carc.), 50 (carc.), 54 (carc.), 61 (primary).

intussusceptions. A chronic intussusception differs from an acute one in the symptoms it produces, but its causation is probably the same; and, as most of these chronic cases are met with during the early and later years of adult life, their omission would affect the age incidence of the various types to a slight degree. These chronic intussusceptions are 19 in number.

It is clear from a glance at these charts that any theory of the causation of intussusception must satisfactorily explain two things: (1) Why all types of intussusception are more common in the first few years of life; and (2) Why ileocæcal and ileocolic intussusceptions are much more common than either enteric or colic.

Let us examine the theories that have been advanced to account for the origin of intussusception, in the light of their ability to satisfy the above two conditions. Broadly speaking, three separate theories have been advanced to explain the method of formation of intussusception: (1) *Perverted peristalsis*; (2) *Paralytic conditions of the gut allowing the prolapse of one portion into another*; (3) *The presence of some congenital abnormality such as a constriction, or new growth such as a carcinoma, acting as the exciting cause.* We exclude Barnard's hypothesis that flexures in the gut and diverticula are causes of intussusception. As Barnard himself points out, 'dimpling in' of a flexure or inversion of a diverticulum must first take place before an intussusception can arise. It is precisely the explanation of this 'dimpling in' or inversion that we are seeking.

1. **Perverted Peristalsis.**—Discussing each of these suggested causes of intussusception in turn, there can be no doubt that perverted peristalsis is one of the ways in which an intussusception may arise. Many surgeons, including the authors, have actually witnessed the manufacture and disappearance of intussusceptions during operation. Again, although in our series only two cases of retrograde intussusception occur, they do occur; others are recorded in the literature, and there is no explanation apart from perversion of the normal movements of the gut to account for them. Further, the frequent occurrence of multiple agonal intussusceptions lends this possibility support. Undoubtedly a certain number of intussusceptions originate in this way. We cannot, however, assume that abnormalities in the movements of the gut will account for most intussusceptions, when the hypothesis is tested against the two conditions just mentioned. The first condition required, that of accounting for the increased frequency of intussusceptions during early life, is fairly well met, granting that, during the earlier years of life, and particularly during the period of weaning, digestive disturbances with—presumably—an associated abnormality in peristaltic movement are most common. The hypothesis, however, completely fails to explain the second question, why the majority of intussusceptions are ileocæcal or ileocolic; for it cannot be assumed that abnormal peristaltic movements are chiefly confined to the ileocæcal valve or the last few inches of the ileum, the two regions where the ileocæcal and ileocolic varieties respectively take origin.

For the hypothesis to hold good that perverted peristalsis is the main causal agent in the production of intussusception, the number of ileocæcal, ileocolic, enteric, and colic intussusceptions should be approximately the same. Reference to the curves shows that this is not so. The percentages of each variety work out as follows: ileocæcal 46·5, ileocolic 37·6, enteric (including those involving Meckel's diverticulum) 10·4, and colic 5·6.

Certainly it may be urged with reason that the ileocæcal valve itself is more likely to act as the apex in any unusual peristaltic movement, owing to the manner in which it projects into the cæcum, and thus the high proportion of ileocæcal intussusceptions can be explained; but the same anatomical peculiarity does not exist in the last few inches of the ileum where the ileocolic variety takes origin.

Perverted peristalsis alone cannot be held to account for the majority of intussusceptions.

2. **Paralytic Conditions of the Gut allowing of Prolapse of one portion into another.**—The same objection applies to this suggestion as to the perverted peristalsis hypothesis. Why should paralytic conditions of the gut occur most commonly at or just above the ileocæcal valve? It is conceivable that the ileocæcal valve, projecting as it does into the cæcum, would more readily prolapse on very slight provocation than any other section of the gut, but the same plea cannot be urged to account for the almost equally numerous ileocolic variety. Furthermore, it is not easy to account for the greater frequency of intussusceptions of every type during the first years of life—the first condition, it will be remembered, that any hypothesis must satisfy—for there is no reason to suppose that paralytic conditions of the gut are any commoner during early life than at any other period of existence.

3. **The Presenceof some Congenital Abnormality such as a Constriction, or of some Growth such as Carcinoma, acting as the Exciting Cause.**—Put in the above form, this hypothesis can be ruled out straight away. It will not account for the greater

prevalence of intussusception during the earlier years of life, for it cannot be shown that either new growths or unusual anatomical conditions are more common early in life. In the case of colic intussusceptions, for example, precisely the opposite is true. In none of our 19 cases during the first seven years of life is a growth recorded as forming the apex of the intussusception, while in the 8 cases which occurred during the age limits of 29 to 61 a growth is described as forming the apex in no less than 7. Still less will this hypothesis account for the preponderance of ileocæcal and ileocolic intussusceptions, for in only 1 ileocæcal intussusception out of 156 is a growth described as being on the valve; and in only 1 ileocolic out of 128, and that a chronic intussusception in a patient, age 68, is a growth—a 'button' carcinoma—mentioned as the apex. Objections could be readily multiplied were such multiplication necessary.

Although new growths and abnormal conditions in the gut-wall can and do excite the formation of intussusceptions, they do not account for the majority.

Method of Formation of Ileocæcal, Ileocolic, and Enteric Intussusceptions.—An examination of the structure of the terminal portion of the ileum and ileocæcal valve at different ages provides, in the case of the ileocæcal, ileocolic, and enteric varieties, the probable solution of the dual problem of, firstly, why intussusceptions are more common during the first two years of life, and, secondly, why the majority of intussusceptions should be ileocæcal or ileocolic. Conclusions drawn from this examination obviously cannot explain either the mechanism of formation of a colic intussusception and the age incidence of this form, or the mechanism of formation of an intussusception of Meckel's diverticulum. The probable method of origin of these last two is given later.

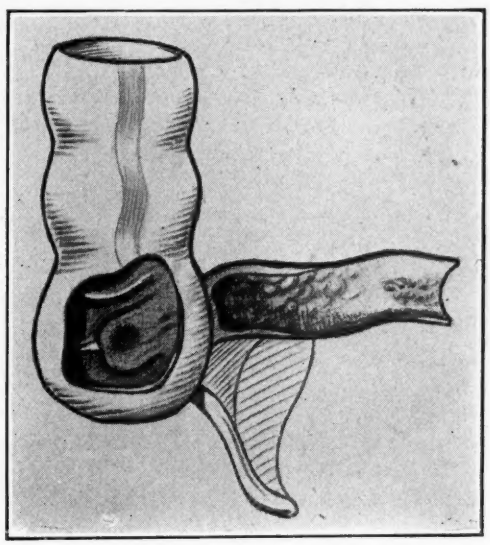

FIG. 59.

Fig. 59, which represents the last few inches of the ileum and the interior of the cæcum with the ileocæcal valve in a child, age three months, shows that the ileocæcal valve is annular in shape, is covered with masses of lymphoid tissue (*Figs.* 46 B, 60, and 61), and projects for some $\frac{3}{8}$ in. into the cæcum. The terminal inch of the mucosa of the ileum is studded with masses of lymphoid tissue which form a complete ring round the lumen of the gut. This aggregation of lymphoid tissue becomes gradually less and less marked as the ileum is examined farther away from the valve until, at a point some 6 in. above the valve, except for isolated Peyer's patches, there is no special aggregation to be found.

In *Figs.* 46 A and 62, which represent the same region of the gut in a child one year old, it is seen that the ileocæcal valve is still prominent, but the patch of lymphoid tissue at the termination of the ileum, though well marked, is less developed.

A consideration of these figures shows that during the first year of life the quantity of lymphoid tissue in the ileocæcal valve, and the degree of projection of the valve into the cæcum, is at its maximum. Both are much less marked during the second year, and the prominence of each gradually decreases as adult life is attained. In other words, the lymphoid tissue and prominence of the ileocæcal valve vary in direct ratio with the incidence of the ileocæcal type of intussusception. A similar relation is seen to exist between the quantity of lymphoid tissue in the last few inches of the ileum and the age incidence of ileocolic intussusceptions. Again, the amount of lymphoid tissue diminishes markedly as the number of ileocolic intussusceptions falls. Furthermore, it will be noted

that the lumen of the last portion of the ileum is relatively small during the first year of life. Now, it has long ago been suggested that an inflamed Peyer's patch might act as the exciting cause of an intussusception. In view of this marked development of lymphoid tissue at and above the ileocæcal valve, and the rapid subsidence of the same during the second year of life, it is impossible not to connect the presence of this lymphoid tissue with the peculiar age and type incidence of intussusception. We think that, in the case of ileocæcal, ileocolic, and enteric types, the majority of intussusceptions are caused by inflammatory swellings of lymphoid tissue. The age incidence is easily explained on this hypothesis, for both lymphoid tissue and intussusceptions are at their maximum early in life, and particularly in the first year of life. The curious anatomical incidence of intussusceptions as shown by the great preponderance of ileocæcal and ileocolic intusussceptions is also explained, for, as the diagrams show, the quantity of lymphoid tissue round the ileocæcal valve is much greater than in any other part of the alimentary canal. The great prominence of the valve, and the narrow lumen of both ileum and — especially — colon during the first year of life* is also probably an accessory factor in the production of these two forms, for any swelling of either the valve or the lymphoid tissue would readily come into contact with the segment of gut immediately below the swelling, and be treated as a foreign body. It is clear that should both the whole collar of lymphoid tissue and valve swell at the same time—no unlikely contingency—† an intussusception will be produced which, on reduction, cannot easily be classified. Sometimes it will be interpreted as ileocæcal, sometimes as ileocolic. Really it is ileocæcal, for of course the valve heads the intussusception. The disparity between our and Fitzwilliams' statistics as to the relative frequency of ileocæcal intussusception may be due to this.

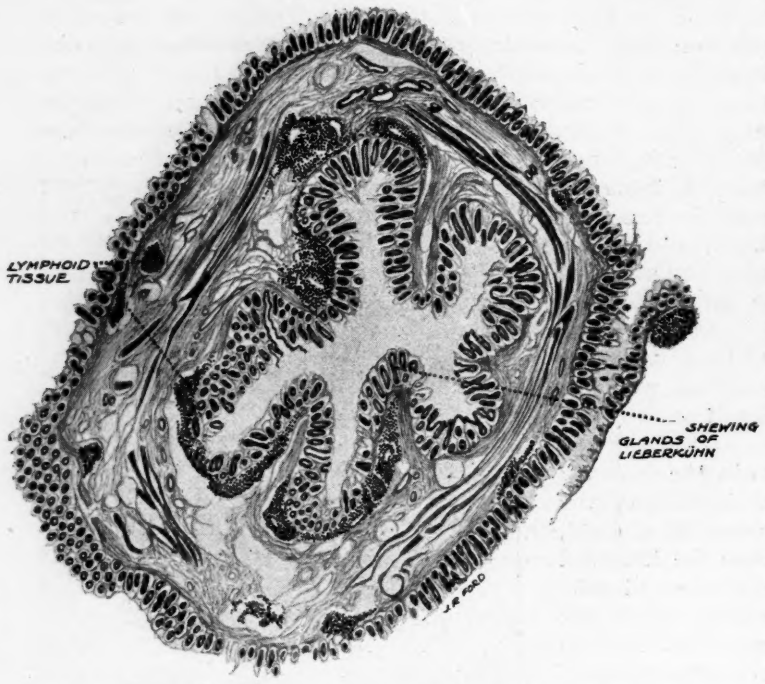

FIG 60.—Transverse section of ileocæcal valve of child, age three months.

The more the above hypothesis is examined, the more is it seen to fit in with the various phenomena which any hypothesis of the causation of intussusception must explain. It agrees, as already pointed out, with the two primary conditions calling for explanation, viz., the greater frequency of intussusception during the first few years of life, especially the first, and the predominance of ileocæcal and ileocolic varieties over all others. Also it squares very well with the optimum age incidence of intussusception, which is during the first twelve months of life, viz., from five to nine months of age, when 50 per cent of all intussusceptions occur. This is the age when teething commences, when the maternal

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* D'Arcy Power[12] has shown that at birth the diameter of the colon exceeds that of the ileum by only a few millimetres.

† Ashhurst[13] has recorded a case in which swelling of this collar produced intestinal obstruction in the absence of any intussusception.

milk is apt to be supplemented or replaced by other foods, and gastro-intestinal disturbances, likely to be associated with swelling of lymphoid tissue in consequence, are rife. Again, the seasonal incidence, which shows maxima in the spring and the period just after Christmas, is adequately accounted for. At both these periods gastro-intestinal disturbances are common. Christmas, even for infants, is frequently a season of injudicious feeding, and the spring, with Easter time, the like. Again, the hypothesis agrees well with the observation that it is nearly always fine fat babies that are subject to intussusception. It is in precisely these children that lymphoid tissue is best developed. At first sight it is curious that, as our statistics show, there is no relation between the seasonal diarrhœa and vomiting of infants and acute intussusception. A closer analysis of the facts, however, reveals that no anomaly exists, for, while it seems reasonable to anticipate that in summer diarrhœa Peyer's patches and lymphoid tissue in general would be considerably swollen, exactly the reverse proves to be the case. Apparently

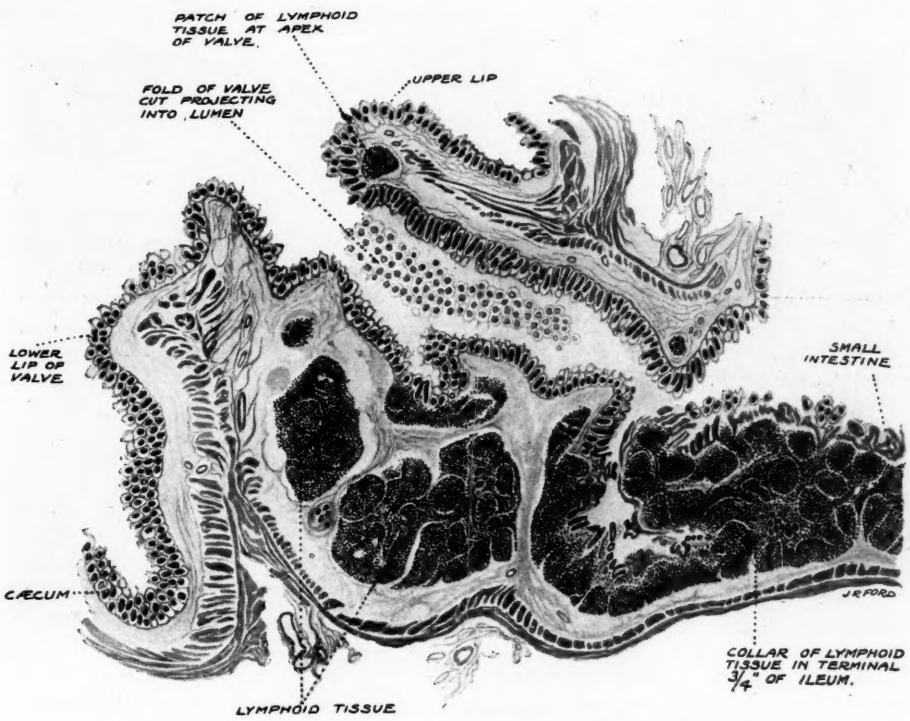
PATCH OF LYMPHOID TISSUE AT APEX OF VALVE.
FOLD OF VALVE CUT PROJECTING INTO LUMEN
UPPER LIP
LOWER LIP OF VALVE
SMALL INTESTINE
CÆCUM
J.R.FORD
COLLAR OF LYMPHOID TISSUE IN TERMINAL 3/4" OF ILEUM.
LYMPHOID TISSUE

FIG. 61.—Longitudinal section of ileocæcal valve of child, age three months.

the inflammation is of such a nature as to produce shrinkage of the lymphoid tissue from the first, presumably by the great abstraction of fluid from the tissues which occurs in this complaint.

The foregoing hypothesis does not explain why males are more affected than females in the proportion of 2·1 to 1. One is driven to take refuge in the observation that male children are more susceptible than female children to all forms of infantile ailments.

One alternative offers itself. The incidence of intussusception has been shown to agree with the relative quantity of lymphoid tissue present in the gut. Male babies are, age for age, larger and heavier than female, and the lymphoid tissue of the gut varies directly with the size of the child. Possibly this is the true explanation of the greater susceptibility of the male.

Causation of Enteric Intussusception.—The origin of the majority is probably to be sought in the swelling of a Peyer's patch. It is interesting to notice, however, how

relatively unimportant isolated Peyer's patches are in exciting an intussusception as compared with the closely-packed lymphoid tissue of the terminal few inches of the ileum, for the total number of acute enteric intussusceptions is only 27, as compared with 126 ileocolics; and of these 27 cases some precedent anatomical abnormality apart from lymphoid tissue, or some new growth, is present in no less than 6, whereas in only 2 of the 126 cases of ileocolic intussusceptions is the presence of a growth recorded. Reference to the curves with their appended lists gives the anatomical conditions found in each variety.

Genesis of Intussusception arising in Meckel's Diverticulum.—A slight modification of Barnard's explanation of the method of production of an intussusception in this region is probably the true one. He considers it arises by the "prolapse of the mucosa lining the diverticulum to a greater or lesser degree into the lumen of the ileum", and cites Hohlbeck's case[14] in which the mucosa was completely everted without inversion of the muscular wall. When one reflects that Meckel's diverticulum is a blind tube, forcible

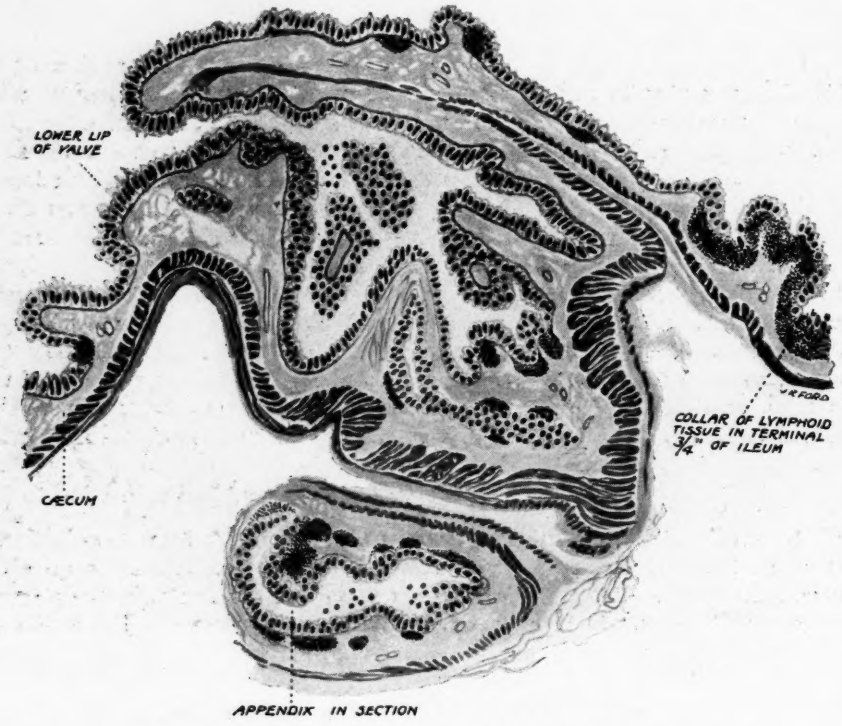

FIG. 62.—Longitudinal section of ileocæcal valve of child, age one year.

eversion of the mucosa into the ileum by contraction of the muscular wall of the diverticulum seems a likely thing to happen. It is, however, a method of formation of an intussusception which can occur in this particular region of the gut alone. Barnard seems to regard the eversion of the mucosa rather as a passive prolapse than the result of a forcible expulsion. Our observations on the firmness with which the mucosa is united to the muscular coat lead us to regard the eversion as more likely to be the result of forcible and prolonged peristalsis.

Causation of Colic Intussusceptions.—Examination of the curve of age-incidence shows that 19 cases occurred before the seventh year, all of which were idiopathic in their origin; that is to say, no growth or other exciting cause could be found to explain their production. After the age of seven, 8 chronic cases were recorded, only 1 of which, however, was primary. All of the remaining 7 could be accounted for by the presence of some new growth which formed the apex. The limitation of primary

colonic intussusceptions to the early years of existence is thus more marked than in the preceding three varieties.

Examination of the colon at different ages reveals no such marked aggregations of lymphoid tissue as explain the origin of our other varieties of intussusception. However, a combination of anatomical conditions exists in early life which is capable of explaining this incidence. Reference to *Fig.* 50 shows that the colic mucosa is thrown into folds which project into the lumen of the gut, which is relatively small. These folds are studded with numerous small lymphoid follicles. *Fig.* 63, a view of the interior of the adult colon, shows that the mucosa has few folds and that the lumen of the gut is much greater than it is during early life. Any localized inflammation of such well-marked folds as exist in the specimen portrayed in *Fig.* 50 would readily produce a swelling which would act precisely as an inflamed Peyer's patch in causing an intussusception. The lymphoid follicles studded over these folds would act as an excellent basis for inflammation. It is in these folds of the mucosa which are well developed that we believe the starting-point of colic

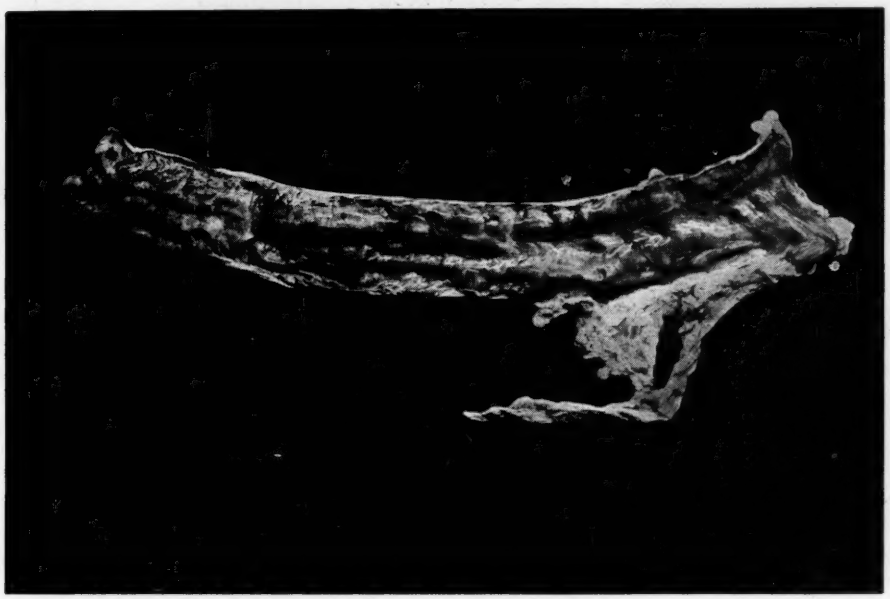

FIG. 63.—Interior view of an adult colon.

intussusceptions is to be found. The limitation of idiopathic colic intussusceptions to childhood is readily accounted for, and the statement, if true, that the majority arise at the colonic flexures, is easily explained.

To sum up, the genesis of colic intussusception depends primarily on the relative excessive development in early life of mucosal folds studded with lymphoid follicles, and on the relatively narrow lumen of the colon, all of which peculiarities almost totally disappear by the age of seven years.* The secondary factor is, as in the case of the other varieties, some intestinal disturbance with its associated rapid change of intestinal flora. Thus there is produced, as the result of swollen lymph-nodes, an increased projection of these folds and a loss of elasticity of the œdematous overlying mucosa, simulating, with more subtle mimicry, to the excited segment of bowel, a foreign body.

That sudden considerable swellings of the colonic mucosa do occur is well known, for it is a commonplace of surgical observation that the factor which converts the chronic

* D'Arcy Power finds that at the age of fifteen the lumen of the colon has increased to between two and three times the size at birth.

obstruction produced by a ring carcinoma of the colon into an acute one is an inflammatory œdema of the mucous membrane. The lumen of the carcinoma ring itself is almost always sufficient to allow of the passage of the intestinal contents.

It is needless to state the objections to perverted peristalsis and paralytic conditions of the gut-wall acting as causes of intussusception in this variety. They are precisely the same as apply in the case of the other varieties.

Briefly recapitulated, the theory above formulated to account for the majority of primary intussusceptions is as follows :—

1. The determining factor is the production of the equivalent of a foreign body within the intestines. This foreign body is provided by the swelling of pre-existing lymphoid tissue. The anatomical and age distribution of the lymphoid tissue in the alimentary canal agrees exactly with the anatomical and age distribution of all primary intussusceptions.

2. The factor that provokes this swelling is some gastro-intestinal disturbance. The secondary maximal incidence which occurs between five and nine months of age is accounted for by this.

3. An important accessory factor in the manufacture of primary colic intussusceptions is the narrowness of the colic lumen early in life. It is largely owing to the threefold increase in diameter of the colon at the age of fifteen that, after the age of seven years, primary colic intussusception becomes excessively rare.

We do not think that there is any one point in this theory that is entirely original, and we freely acknowledge our debt to previous writers. For example, Walton has emphasized the aggregation of lymphoid tissue in the lower end of the ileum, which he rightly compares with the sacculus rotundus of the herbivora, and its relation to the frequency of ileocæcal and ileocolic intussusceptions. Fitzwilliams has pointed out the importance of the influence of the teething period, and D'Arcy Power has described the variation in the diameter of the colon with age. When all these observations are pieced together and envisaged as a whole, a tolerably complete hypothesis emerges to account for all the various phenomena of seasonal, type, and age incidence that intussusception presents.

SYMPTOMATOLOGY.

Consultation of our list of cases brings a few new facts to light. Comment has already been made by other authors on the extraordinary uniformity in the symptoms of acute intussusception in children under twelve months of age. This our records fully confirm. Plump, healthy children are usually attacked with spasms of violent abdominal pain which produce screaming and drawing up of the legs. Constipation may be absolute, but sometimes the colon empties itself at the start and one or more normal motions are passed. After that, only blood and slime are seen, very occasionally accompanied by small quantities of fæcal matter as well. Both slime and blood are probably the products of the intussusceptum. Vomiting is frequent, and usually occurs during the attacks of pain.

As an example of the constancy with which these typical symptoms recur, we find that in 89 per cent of our cases the presence of blood, or of blood and slime together, are mentioned. This is a remarkable percentage when one considers that the list does not consist of carefully investigated cases with histories taken with the special view of ascertaining the typical symptoms of the disease. The histories are only those taken by the hard-worked house-surgeon during the busy period of 'full duty', when there is little time for accurately investigating symptoms, or at any rate for minutely recording them.

In 63 per cent of our cases* a lump was felt in the abdomen, either under the

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*The proportion of cases in which a tumour can be identified on careful examination is undoubtedly higher than our statistics show, for our series must contain many cases in which a tumour was palpable but its presence was not recorded in the notes.

Lett[15] in his carefully investigated series of 24 cases felt a tumour in every one, while Barnard gives 75 per cent, and MacAdam Eccles 80 per cent, as the proportion in which a tumour can be felt.

anæsthetic or, more usually, without. In a fair number of cases specific mention is made that a lump was sought for but not discovered, even under anæsthesia. It is quite obvious that intussusceptions can be quite easily tucked away under the liver, especially at the hepatic or splenic flexures, and impossible to feel even under an anæsthetic. Though more often present than not, the absence of a palpable tumour should never bias the surgeon against laparotomy in cases where a typical history points to the presence of an intussusception.

In one case in our records with a typical history, an intussusception concealed under the left lobe of the liver was missed at operation. This shows the need for care in searching for an intussusception in the presence of a characteristic symptomatology, though as a rule but little difficulty is encountered in finding the tumour once the abdomen has been opened.

Our records bring to light one small point of some interest which seems to have escaped observation. It is known that frequently an intussusception presents at the anus. According to the different construction of ileocæcal and ileocolic varieties of intussusception one would expect that of the two the ileocæcal variety would more frequently present at the anus. This is found to be the case. Of the 156 ileocæcal intussusceptions, 42, or 26·9 per cent, are described as either just inside the anus or actually protruding from it. Of the ileocolic, only 16 of the 126 reached a similar position, i.e., 12·7 per cent. In general the ileocolic intussusceptions do not progress as far down the gut, presumably owing to the obstacle presented by the ileocæcal valve, for we find 35 ileocæcal intussusceptions, i.e., 22·4 per cent, reaching the splenic flexure, while only 10 ileocolics, i.e., 7·9 per cent, did the same. Adding these figures together, we find that in 49·3 per cent of the ileocæcal variety the intussusception is recorded as reaching the splenic flexure or beyond, while in only 20·6 per cent of the ileocolic variety did the intussusception travel as far.

It is extraordinary, in the case of the ileocæcal intussusception, how soon after the onset of symptoms the valve may reach the anus. It is quite common to find that after a history of 18, 16, or even 10 hours the intussusception can be felt in the rectum, nor does the distance the intussusception has travelled render the prognosis necessarily bad. As we shall have occasion to show, length of duration of the intussusception is the main factor in increasing mortality.

Apart from this difference in the position of the lump, we are inclined to think from our own experience that the symptoms presented by patients with an ileocolic intussusception are more severe than those with an ileocæcal.

General conclusions drawn from a small number of cases are proverbially dangerous, but this impression of ours derives support from a consideration of the length of the history in the two types. Of the 156 ileocæcals, the length of the history was given in 101 cases and averaged 38 hours; of the 126 ileocolics, it was available in 109 cases and averaged 33 hours. The difference is perhaps not great, but as far as it goes is in favour of the ileocolic intussusception producing severer symptoms than the ileocæcal. In hospital practice the time at which a case is sent into hospital depends largely upon how alarming the condition of the patient appears in the eye of the practitioner, and thus one would expect the ileocolic variety to present itself sooner for treatment than the ileocæcal.

In practice we find that the ileocolic variety presents the following symptoms as compared with the ileocæcal: the condition of the child is worse as compared with the length of duration of the symptoms, and the lump is not so far advanced. It is thus frequently possible to diagnose the precise type of intussusception before opening the abdomen.

In the case of the enteric variety, which, as a reference to the chart of the age incidence shown in *Fig.* 57 will show, occurs more frequently in older patients, the symptoms are much less severe than in either the ileocolic or ileocæcal form. In consequence, we find that the average duration of symptoms before operation is longer, viz., 84 hours. Of the 27 enteric intussusceptions on our list the length of the history was recorded in 23.

OPERATIVE TREATMENT OF INTUSSUSCEPTION.

The following table, giving the various operations that have been performed, is self-explanatory and needs but little comment. The varying mortalities for the different operations merely reflect the seriousness of the condition that called for their use. For example, reduction with appendicectomy claims a larger number of victims than simple reduction only because the intussusceptions had existed for so long that the appendix had become gangrenous. The mortality is the mortality of the condition rather than that proper to the operation.

Table IV.

Nature of Operation	Total	Died	Death-rate
			per cent
Laparotomy with reduction	309	69	22 3
Reduction with appendicectomy	18	6	33·3
*Resection with anastomosis by clamps	29	20	68·9
Laparotomy. Attempted reduction or anastomosis. Sewn up	12	12	100
Resection with Paul's tube	12	12	100
Resection with Murphy's button	6	6	100
Paul's tube	4	4	100
No operation	7	7	100
Resection { ? Paul's tube / ? Anastomosis	2	2	100
	400	139	34·75

* The nine cases which recovered were all over the age of three years.

It is noteworthy that when an intussusception is irreducible, the only form of treatment that has been attended with any success is excision and end-to-end or side-by-side anastomosis with clamps. Although Dowd[16] has collected eight cases of successful resection in children under one year of age up to the end of the year 1913, the youngest patient in our series to survive excision and anastomosis was three years old. The majority that lived were much older.

All cases treated by drainage with a Paul's tube died either from shock shortly after the operation, or from exhaustion a few days later. In one case treated by the insertion of a Paul's tube above an irreducible intussusception, the post-mortem records show that the tube was placed, not above, but below, the intussusception. As far as the end-result is concerned, it matters little on which side of the intussusception the tube is placed: we record the incident only to show how easily this mistake may be made, and to assist the surgeon to avoid the wound to his *amour propre* that such a proceeding entails. It would probably be safest to trace the gut from the ileocæcal valve upwards to the intussusception whenever this desperate measure is the operator's only resource, as there is commonly but little distention to aid in distinguishing the proximal from the distal coil, and even the anatomy of the intussusception may mislead, for there is no guarantee that a retrograde form is not being dealt with.

Cases treated by anastomosis with Murphy's button yielded a like 100 per cent death-rate. The last anastomosis done with a Murphy's button was in 1913. Examination of the post-mortem records show that even had the patients not died from shock shortly after the operation, the button was not likely to have relieved the condition, for, of 3 cases which came to post-mortem examination, in 2 the gut adjacent to the button was gangrenous, presumably from pressure, and in the third the anastomosis is recorded as leaking from one third of its length. In all, the gut above the anastomosis was much dilated.

Apart from the points already enumerated, the post-mortem records yield one or two hints as to operative treatment.

Occurrence of Volvulus after Operation.—In 2 cases, after a successful reduction,

laparotomy had to be performed again to relieve the obstruction caused by, in one case, a volvulus of the small intestine, and in another a volvulus of the large and small intestine together. It is well known how often both small intestine and large have a common mesentery in young children, and care in returning the gut into the abdomen is thus indicated.

Adherence of Gut to the Abdominal Incision.—In 3 cases the abdomen had to be re-opened owing to the adherence of small gut to the abdominal incision. It has been a very general practice to sew up the abdomen with through-and-through silkworm-gut sutures with the idea of saving time and thus shock. With this method it is by no means easy to make certain that no gut is caught in the wound, and we believe it is to this method of suture that this accident is due. We ourselves always sew the peritoneum separately. Even in small infants the peritoneum is strong and holds the stitches well, the proceeding is easy, and administration of the anæsthetic can be discontinued immediately the peritoneum is united. We believe the length of time the patient is under the anæsthetic is actually less than when through-and-through sutures are employed.

Gangrene of Gut after Reduction.—In 10 cases of successful reduction, the post-mortem findings record that the gut was gangrenous. Resection was evidently necessary; but in view of the fact that the lowest age at which a successful resection has been performed in our series is three years, and that only 8 successful cases are recorded in the literature, there is obviously much to be said for leaving doubtful gut in children under this age.

POST-OPERATIVE RESULTS.

As a rule, after reduction, convalescence is rapid and uneventful apart from such very occasional accidents as have been mentioned in the preceding section. There is, however, one feature of convalescence that does not seem to have attracted much attention, and this is the very high reactionary temperature which is so frequently observed. The temperature, usually subnormal on admission, commonly rises to 101° or 102°, and exceptionally to 104° or even 106°, after operation.

We find that 56·1 per cent of the ileocæcal and 41·9 per cent of the ileocolic type reached a temperature of 101°; 38·7 per cent of the ileocæcal and 28·2 per cent of the ileocolics a temperature of 102° after operation. This temperature is far higher than that observed after ordinary operations such as radical cure for an inguinal hernia in young children. It is obvious that after reduction of an intussusception there is much œdema of the gut-wall which must be absorbed, and probably also other toxic products are formed in the damaged gut-wall. That the ileocæcal variety should exhibit more examples of a high temperature than the ileocolic is only to be anticipated, for the intussusception is as a rule more extensive and covers a larger area of gut, and thus produces more toxic bodies for absorption.

It will be remembered that, while 49·3 per cent ileocæcal intussusceptions reach the splenic flexure or beyond, only 20·5 per cent ileocolics do the same. In many cases it is this liberation of toxins into the blood-stream which tips the patient over the razor edge which separates recovery from death.

MORTALITY.

Total Mortality.—For the whole period of eighteen years there were 139 deaths out of the 400 cases treated, giving a percentage death-rate of 34·75.

Cuthbert Wallace,[17] in his series of 20 cases, had a mortality of 20 per cent; Barker[18] a mortality of 40 per cent in a collected hospital series, and in his own series 28 per cent only; Sargent,[19] in a series collected from St. Thomas's Hospital Reports, 61 per cent.

The subsequent discussion on operative results will show, however, that the factor on which the mortality of any series depends is less the skill of the operator than the length of the history before operation is performed. Thus, 21 cases of intussusception were operated on at the London Hospital in the year 1915 by eleven different surgeons with a mortality of only 14·3 per cent. The excellence of this result was due to early diagnosis.

Sex.—As is only to be anticipated, the mortality is practically the same for both sexes. Of males, 93 died of a total of 272, giving a death-rate of 34·1 per cent; while 46 females died out of a total of 128, giving a death-rate of 35·9 per cent.

Mortality in Relation to Type.—*Table V* gives the mortality in the case of each type :—

Table V.

Type of Disease	Total Cases	No. of Deaths	Mortality per cent
Enteric	27	15	55·5
Ileocæcal	156	51	32·6
Ileocolic	126	39	30·0
Colic	19	3	15·7

It is seen that the mortality is highest in the case of the enteric, and lowest in the case of the colic variety, the ileocæcal and ileocolic varieties occupying an intermediate position.

At first we were inclined to think that the explanation of this curious difference lay in the readiness or otherwise of each form of intussusception to become irreducible. It is tempting to suppose that, owing to the greater diameter of the colon, a colonic intussusceptum has less tendency to be tightly gripped and thus form adhesions between the entering and returning layers than an enteric. The low mortality of the ileocolic variety, however, definitely negatived this hypothesis, for the pressure upon the intussusceptum should be just as severe in this type as in the pure enteric. An examination of the symptomatology of the various types provided, however, the key to the puzzle. As already mentioned in the section on symptomatology, the average length of history in the four types is as follows :—

Enteric	84 hours	Ileocolic	33 hours
Ileocæcal	38 „	Colic	33 „

Thus the mortality runs precisely parallel with the length of the history; and the curious paradox manifests itself that the type of intussusception which produces the milder symptoms is ultimately the most fatal, for it remains longer unrecognized, and thus time is given for it to become irreducible through the formation of adhesions. An accessory factor in the production of the high mortality of the enteric intussusception is the difficulty in feeling a lump, for in only 8 of the 27 enteric intussusceptions was a lump felt, while in 14 of the 19 colic intussusceptions the tumour formed by the intussusception was identified. The percentages are 28·5 and 73·6 respectively. The following table gives the total number of cases, mortality, length of history, number of resections, and percentage of cases in which a tumour was felt respectively :—

Table VI.

Variety	No. of Cases	Mortality per cent	Length of History	Resections	Tumour per cent
Enteric	27	55·5	84 hrs.	16	28·5
Ileocæcal ..	156	32·6	38 „	14	74·3
Ileocolic ..	126	30·0	33 „	11	59·5
Colic	19	15·7	33 „	1	73·0

It will be observed that a perfect parallel is preserved between each of the four last columns. It is incidentally worthy of note that every death among the enteric

intussusceptions followed a resection. There were 16 resections in all; 1 recovered, 15 died. On the other hand, each of the 12 cases in which the intussusception was reduced recovered.

Triennial Mortality.—*Table VII* gives a comparison of the mortality for each triennial period of the eighteen years surveyed :—

Table VII.

Year	Total Cases	Deaths	Mortality per cent
1903–05 ..	74	42	56·7
1906–08 ..	64	26	40·6
1909–11 ..	68	23	33·8
1912–14 ..	81	18	20·9
1915–17 ..	67	12	17·9
1918–20 ..	46	18	39·1

The steady fall in the death-rate is a most astonishing feature of this table, and the rise for the last triennial period is almost equally remarkable. As the treatment throughout these eighteen years has been without exception operative, either operative technique or diagnosis must have improved to account for this diminution in mortality. Tables compiled from the registers of the operating theatres show that the average time occupied in performing the same kind of operation in the later is no less than that occupied in the earlier years. Surgeons were as skilful in 1903 as in 1915. Increase in operative skill cannot therefore account for the reduction in the death-rate, and we are driven to seek some other explanation.

A comparison of the average length of the history before the patient reached the operating table supplied the clue to the problem. *Table VIII* gives the total mortality for each of the triennial periods, the average length of the history for all the cases of each triennial period in which such could be obtained, and also the percentage mortality in those same cases.

Table VIII.

Year	Total Cases	Total Death-rate	No. of Cases in which Duration was Traceable	Mortality per cent	Length of History in Hours	Resections
1903–05 ..	74	56·7	61	59	46	14
1906–08 ..	64	40·6	42	38	35·8	12
1909–11 ..	68	33·8	39	27·9	33	12
1912–14 ..	81	20·9	55	20	29	11
1915–17 ..	67	17·9	46	19·5	26	2
1918–20 ..	46	39·1	32	26·5	32	7
Totals ..	400		275			

It is seen that the resemblance of the two sets of figures is very close. The percentage death-rate for the cases in which the average length of the history can be ascertained is slightly different from that for all the cases admitted during the same period, but there is not much discrepancy, and the death-rate varies as regularly with the rise or fall in the length of the history in the one set as in the other. The obvious explanation of the change in the death-rate is to be sought in the answer to the question why the length of the history varies.

Several hypotheses suggested themselves, only to be rejected on consideration, and

the conclusion finally reached is that the outside practitioner is probably responsible for the varying periods at which the patients are sent up to the hospital. From 1903 to 1917 the steady improvement in the statistics is probably due mainly to increase in the number of doctors available for attending the population around the hospital, and possibly also to improved education. It must be remembered that rectal injections as a treatment for intussusception have only ceased to be carried out in the last twenty years,* and thus after this date there must have been many practitioners surviving who from early training failed to appreciate the need for early operative intervention. With the passage of time their views would have gradually changed until the present attitude of mind would have been universally reached, in which any child with diarrhœa and vomiting is regarded with a suspicious eye as a possible sufferer from an acute intussusception. The regrettable increase in the mortality during the last triennial period, 1918–1920, is probably due to the extensive withdrawal of doctors for the army during the latter part of 1917 and early months of 1918. This has probably righted itself at the time of writing (December, 1920), but the more favourable statistics of 1920 have not made themselves felt, for they are not completely incorporated in this last triennial period, as only the first 7 cases admitted in 1920 are included in the series in order to keep the total number considered at the round figure of 400.

Possibilities of failure in the hospital organization for the treatment of emergencies were carefully reviewed by us, but none manifested themselves. By hook or by crook, the most expert surgical assistance was always available throughout the war for civilian patients, and throughout the whole of the eighteen years surveyed an intussusception has always been regarded and treated as a surgical emergency requiring immediate relief.

Consideration of the varying mortality during the eighteen years thus shows that it lies in the hands of the practitioner to reduce the mortality of acute intussusception from 56·7 per cent to 17·9 per cent by early diagnosis of the condition. Comparison of the best and the worst individual years of our series yields an even more remarkable difference still. In 1903, 21 cases were treated, of which 13 died. In 1915, 21 cases were also treated, of which only 3 died. The difference in the mortality is that of 61·9 per cent as compared with 14·2 per cent, or, in other words, 10 more good lives were saved in 1915 than in 1903.

LITERATURE.

We have only appended a list of those papers to which actual reference has been made in the text, though many more have been consulted. A short account of a few of the points gleaned may be of interest. The most important early paper we can find is Leichtenstern's monograph in the *Prager Vierteljahresschrift.* As one of many good things, he gives a most complete list of literature, which even then was immense, up to the date of writing, 1873. It is interesting to note that, with characteristic Teutonic thoroughness, he refers to Fabricius Hildanus's[21] paper on prolapse of the uterus written in 1676. In John Hunter's[22] paper, it is of some interest to note that he styles intussusception 'introsusception'. Rokitansky[23] is responsible for the change of the term to intussusception, and the introduction of the terms intussusceptum and intussuscipiens. Sir Jonathan Hutchinson, in 1873, records the first successful case of laparotomy in Britain, one performed by himself; and cites others, notably one performed in 1874. He says, " intussusception was diagnosed by Nuck, at whose suggestion operation was performed; in the performance of this operation the intestines were fomented with tepid milk and the intussuscepted part was well oiled. It is spoken of as having been very easy of performance ". The lady recovered. A most interesting series of cases collected by Waren Tay is appended, among which we read that during the treatment of intussusception in a child, age 4,

* In this connection, it is interesting to note that as late as 1910, in the discussion on a paper by Childe in the *Trans. Soc. Med.*, July, 1910,[20] a well-known practitioner makes the statement: " I have used inflation in all my cases, and with satisfactory results ".

" clysters had no effect. After eight pumpings with the bellows a loud report was heard. The next day there were signs of the tumour returning, but the whole disappeared after inflation ".

Corner's paper[24] contains the most detailed system of nomenclature for compound intussusceptions we have discovered.

For the literature after Leichtenstern's time, Walton's admirable article in the *Practitioner*[25] should be consulted.

We beg to tender our thanks to many of our colleagues for their helpful suggestions ; to Mr. A. J. Walton for his valuable assistance in the voluminous literature of the subject, to Mr. William Morris for his kindness in elaborating the diagrams, and to Dr. W. W. Woods, of the London Hospital Pathological Institute, for his help in the preparation of sections.

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SUPPURATING TERATOMATOUS CYST IN THE SPLENIC REGION.

By W. G. SPENCER, London;

With Pathological Report by J. A. BRAXTON HICKS,

assisted by SEAGER THOMAS,

and confirmed by S. G. SHATTOCK, London.

H. D., a married woman, age 49, was admitted to the Westminster Hospital on June 20, 1917. She was extremely exhausted as the result of long-standing suppuration, which on first examination appeared to be the result of an empyema in the left pleural sac.

History.—This was as follows: She had had three children, the last in 1912. All her pregnancies had been normal and her confinements without incident. She had had no miscarriages, and, when not pregnant, menstruation had been regular. Previous to these pregnancies, in 1900, she had undergone laparotomy through an epigastric incision corresponding to a mesial linear scar of about three inches in length (*Fig.* 64, *a*). After the exploration she was told she had a 'fibroid growth' which could not be removed. From that time she could always feel 'a lump' in her left side.

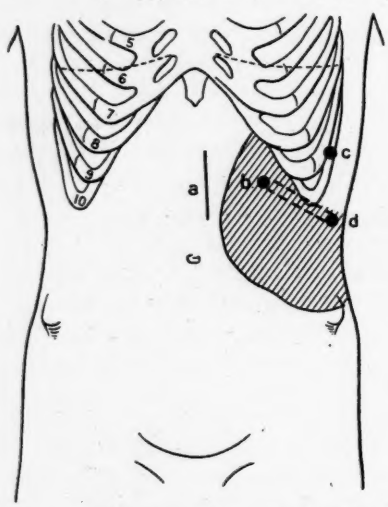

Fig. 64.—Diagram of the cyst and of the various incisions.

During 1916 the above 'lump' began to get larger until the Christmas of that year, when it burst at an opening present in the left hypochondriac region, marked *b* in *Fig.* 64. She was subsequently operated on through the left posterior scapular line, below the 9th rib, for an empyema, the narrow sinus of which operation persisted (*Fig.* 64, *c*).

On Admission.—The patient presented a well-defined mass in the left hypochondrium and the sinuses and scars already mentioned.

Blood-count. (J. A. B. H.).—Hæmoglobin, 32 per cent; red corpuscles, 2,330,000 per c.mm; white corpuscles, 10,000 per c.mm; polymorphonuclears, 70 per cent; monomorphonuclears, large, 8 per cent; monomorphonuclears, small, 22 per cent.

Urine. (J. A. B. H.).—Albumin present, 0·01 per cent; urea, 1·4 per cent. Deposit contains numerous hyaline casts.

The condition was thought to be one of left-sided empyema, which had tracked down behind the diaphragm.

With the idea of promoting better drainage a small amount of general anæsthetic was given; but as the patient stopped breathing it was only possible to make a hasty counter-opening by passing a probe from the sinus *b* (*see Fig.* 64) backwards, below the 12th rib. Into this a large drainage tube was inserted (*see Fig.* 64, *d*) after respiration had been restarted. Pus containing decomposed blood and débris drained freely from the tube, and the patient made improvement enough to encourage further operation.

On July 3, under a general anæsthetic, the empyema sinus (*Fig.* 64, *c*) was explored, but no communication was found with the abscess below the diaphragm. The sinus in

FIG. 65.—To show the teratomatous mass and the matted hair removed from the cyst.

FIG. 66.—Skiagram of the teratomatous mass removed from the cyst.

the left hypochondrium (*Fig.* 64, *b*) was next enlarged and some three quarts (3 litres) of pus, mixed with decomposing blood, evacuated. Further exploration revealed a hard mass consisting of portions of bone and cartilage, undergoing maceration. In addition, hair and a flesh-like mass could be detected, and a piece of bone free in the cavity, which was removed. This piece of bone resembled a fœtal tibia and fibula. Nothing further was done at the time, except to insert a large drainage tube.

As soon as the patient had recovered from the anæsthetic and the operation, an *x*-ray photograph was taken, and this revealed a bony and cartilaginous mass, suggesting a partially calcified fœtus.

On Aug. 2 a further operation was undertaken, the abscess cavity in the left hypochondrium being thoroughly opened up, and all the fœtal contents removed. The cavity was sponged out and packed. The patient did not stand the operation at all well, and there was no improvement. Death occurred on Aug. 18.

Post-mortem Examination (J. A. B. H.).—The patient was greatly emaciated, and presented the scars and sinuses already enumerated.

Thorax.—Right lung showed nothing noteworthy, but the left lung was firmly adherent to the diaphragm and lower part of the pleural sac. Two sinuses led into the left pleural sac, one from the skin in the region of the 9th rib posteriorly (*Fig.* 64, *c*), and the other, never discovered during life, from the pleural sac into the abscess cavity in the left hypochondrium. This latter sinus passed through the diaphragm, and indicates that the empyema was secondary to the abdominal abscess.

Heart: Nothing noteworthy.

Weights: Right lung, 9 oz. Left lung, 12 oz. Heart, 8 oz.

Abdomen.—With the exception of changes due to prolonged fever and suppuration, the liver and kidneys showed nothing noteworthy. There was no evidence of lardaceous disease. The gastro-intestinal tract was normal, and the whole of the abscess cavity, to be described later on, was retroperitoneal, the actual peritoneal cavity itself being quite clean and free from adhesions. Ureters and bladder, nil. The pancreas was present, but all efforts to trace the spleen failed.

Weights: Liver, 47 oz.; kidneys, 3 oz. each. The uterus and both ovaries were present and normal.

Cyst and Contents.—Occupying the left hypochondrium, and placed well away under the rib margins was an ovoid cavity. The dimensions of this cavity were 7 in. (18 cm.) in one of the diameters, and 5–6 in. (13–15 cm.) in the other. The wall of this cavity was placed entirely behind the parietal peritoneum. The lower pole was just in front of the upper fourth of the left kidney, from which, however, it was easily separable. The inner side of the sac was in close relation to the tail of the pancreas, from which it could be readily stripped off. The anterior aspect was firmly united to the under surface of the lower ribs, and to the abdominal wall just below their margins; while the upper and posterior aspects of the sac were formed by the left cupola of the diaphragm. Through the diaphragm passed a sinus leading into the left pleural sac, which has been already mentioned. The wall of the sac was uniformly about 4 mm. thick, and the inner surface presented a somewhat skin-like appearance, being everywhere coated with a layer of pus.

Microscopically, the wall of the sac was found to be composed mainly of condensed fibrous tissue; in a few places, however, true skin with sebaceous glands and hair follicles was present.

The contents in life of this sac were: (1) Pus; (2) Matted strands of long hair; (3) Fat and sebaceous material; (4) The teratomatous mass.

The first three need no particular discussion.

The teratomatous mass was in an advanced state of development, as can be seen from the photograph (*Fig.* 65), which should be compared with the skiagram (*Fig.* 66). The specimen studied thus seems to show a narrower portion, which might be a femur, to which are attached about three digits. It will be remembered that bones resembling a tibia and fibula were removed from the cyst, but they were unfortunately lost. About

the middle is a sort of pelvis, then a rod of bone enlarging into an irregular mass of bone like a crocodile's head. Coming off from the middle of the larger mass is a pedunculated structure, also containing bone. The coverings of both these masses are skin, with the appendages and a ball-like mass of long hair matted together by sebaceous material. No dissection has been attempted, as such a course would have of necessity spoilt the specimen, and we doubt very much if any scientific gain would have been achieved.

This cyst containing fœtal elements would seem to be an example of a teratomatous cyst arising in an unusual situation. Similar examples have been recorded, but the condition is of such rarity that the publication of the case seems to us to be justified. There is no reason why a teratomatous cyst should not arise in this situation, if the theory of origin as 'mistakes' in development of tissues derived from the germinal area of the mesoblast is accepted. In the fœtus, a large mass of mesoblastic tissue exists in the renal region; at first undifferentiated, it is later split off into ovarian (or testicular) and renal tissue. The ovarian (or testicular) portion later descends into the pelvis, and it is not beyond our imagination to accept the theory that a teratoma such as this is the result of some of the germinal area being left behind when the descent into the pelvis occurs. What starts the growth of such a mass of cells into an imitation of fœtal structure such as this and other teratomata is unknown. The extraperitoneal situation of the cyst, in close relation to the left kidney, and to the spleen, which apparently it had obliterated, since this organ could not be found, supports the views enunciated above. The suggestion that it might be an ectopic gestation is negatived by: (1) The presence of absolutely normal uterus and appendages; (2) The situation of the cyst; (3) The contents—a mass of hair—many of the individual hairs being some inches in length; (4) Normal and uneventful pregnancies since the lump in the left hypochondrium was originally felt (first in 1900, last pregnancy in 1912); (5) The integrity of both ovaries further shows that the teratomatous cyst did not arise in either of these organs, and subsequently became dissociated and displaced into the splenic region; (6) The formation differs from retroperitoneal forms of fœtus in fœtu or ischisis fœtatis *var.* abdominalis, in that the enveloping sac consists in part of true skin which has evidently produced the long hairs shed into the cavity.

Looking back on the case, it seems that before suppuration supervened the cyst might have been removed more easily than an adherent enlarged spleen, because of the absence of large vascular connections.

TUMOURS OF THE SALIVARY GLANDS, WITH THEIR AFTER-HISTORY.*

By R. KENNON, Liverpool.

Salivary-gland tumours, though not of frequent occurrence, share with sebaceous cysts and ganglion a peculiar power to elicit in their possessors a morbid delight in their presence, with its attendant self-pity. This, with the luxury of an ever-sympathetic group of friends, makes them blind to the hideousness of their deformity and deaf to the warnings of the profession as to the ultimate outcome of this silent death. The knowledge of surgical failures, in patient and doctor alike, has weakened the demand for treatment; and the object of this research was to investigate the after-history, causes of recurrence, and the pathological nature of salivary tumours, and to demonstrate that, in the majority of cases, surgery can cure.

The material consisted of 124 cases of parotid tumours and 13 cases of submaxillary tumours, collected from the Thompson Yates Pathological Laboratory and the records of the Royal Infirmary.

The 124 cases of parotid tumour were classified as follows: *Adenomata*, 91 cases, including a case of lymphangioma and one of inflammatory origin; *Carcinomata*, 27 cases; *Sarcomata*, 6 cases.

ADENOMATA.

Out of the 91 cases of simple tumour, the after-history of 32 has been traced; of these, 29 were operated upon over five years ago. Of the 32 cases in which an after-history was obtained, 22 are alive and well; 1 died of an unknown cause; 1 died of angina pectoris without recurrence seven years after the operation; 5 have recurred; 3 under the five-year limit are also alive and well. In other words, 71·9 per cent have survived the five-year limit, while 15·6 per cent have recurred. The average duration of known cure was well over eleven years.

Etiology.—The age at the onset of disease (data available in 29 cases) averaged 30·1 years (youngest 16 years, oldest 54). Age at the time of operation (43 cases) 37 years (youngest a case of lymphangioma age 13, another age 15).

It is interesting to note that the persuasive influence for good of a doctor over his patient in these cases varies from 9 months to 20 years, and averages 7 years. Out of 78 cases, 59 occurred in women, 19 in men. No family history of similar tumours was obtained.

Trauma.—Out of 29 cases in which a record is available, 4 gave a previous history of blows on the cheek, etc. Mumps, scarlet fever with tonsillectomy, figure in individual cases.

Pathology.—Macroscopically the tumour is lobulated, partly solid and partly cystic, occurring on either side of the face without much distinction (left 21, right 27), bilateral in two cases, multiple in one. The heaviest recorded weight was 3 lb. 10 oz., removed by Mr. Rushton Parker; but at that time malignant change had probably taken place, and early and repeated recurrence followed (*Fig.* 67). Keen reported a case in which the tumour weighed 7 lb.

Much has been written on the origin of these tumours, and their terminology has changed with the prevailing pathological whim: they have been styled mixed tumours,

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* A paper read on January 28, 1921, before the members of the Liverpool Medical Institution.

endotheliomata, embryomata, teratoblastomata. The amount of indefinite evidence for these names contrasts vividly with the decided opinion I obtained from Mr. Paul and Mr. Thelwall Thomas that primarily the lesion is an adenoma. Examination of over seventy sections leads me to agree with them, and I recognize two types : *the diffuse* and *the acinar*.

FIG. 67.—Adenoma of 37 years' duration, weight 3 lb. 10 oz., removed by Mr. Rushton Parker. Finally carcinoma ensued.

The diffuse type is illustrated in the case of Miss J. M. (*Fig.* 68), who noticed a swelling on the left side of the face at the age of 51. Two years later, Nov. 1909, it was removed by Mr. R. A. Bickersteth. In July, 1920, she was alive and well [2313]. It is also illustrated by *Fig.* 69, a recent case ; this tumour was removed by Mr. R. E. Kelly.

FIG. 68.—Diffuse type, onset at age of 51, removed two years after, 1909, alive and well 1920.

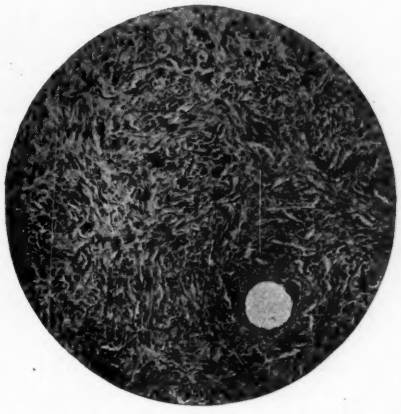

FIG. 69.—A similar case to that in *Fig.* 68, but more recent.

The acinar type is shown in *Fig.* 70—Miss D. B., age 19, a recent case of typical 'mixed tumour', removed by Mr. Litler Jones. For a time I was disposed to think the latter were of duct origin, while the former arose from gland proper ; but closer study showed that both diffuse and acinar formations occur in the same tumour. Frazer[1] believes these tumours are duct adenomata. The course of events seems to be an adenoma,

mucinous degeneration with epithelial or degenerative cyst formation, inspissation or liquefaction, necrosis, and, later, formation of cartilage. In innocent growths I did not find any outer layer of basal cells, though such is present in many cases of cancer. The anatomical view that the cartilage is derived from branchial clefts has little evidence to support it. Purely bone or cartilaginous tumours do not occur in this series, and sarcomata form only 5 per cent of the malignant cases.

The endotheliomatous origin of these tumours I have not dealt with, but endothelium can often be seen in the smaller blood-vessels and the capillaries presenting no atypical appearance. To support this theory of origin it is necessary to imagine a flat scale-like cell, under an unknown stimulus, changing into a sphere or cube, and, though derived from mesoblast, capable of producing carcinoma in the majority of cases when malignancy ensues: and one must imagine also a differential stimulus capable of exciting to over-growth the ill-defined and little-known perivascular endothelium, yet leaving intact that of the normal blood-vessels and capillaries.

Fig. 71 shows an adenoma with well-defined acini, distended with mucus, removed from Miss N., age 50 at time of operation, by Mr. Thomas in December, 1912. Reported "quite successful", November, 1920 [1991].

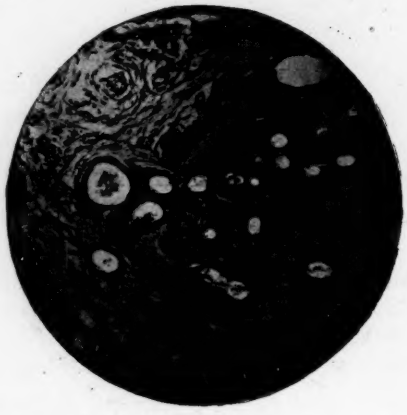

FIG. 70.—Acinar type of parotid adenoma, at age of 19. Recent case.

FIG. 71.—A similar case to *Fig.* 70; acini distended with mucus

Fig. 72 shows the second stage of the diffuse mass, mucinous degeneration, from D. J., male, age 41, in 1907. The tumour appeared in 1901 on the right side of the face. It was removed nine months later and diagnosed cancer. It recurred, and was again removed in 1904, with immediate recurrence. Yet simple enucleation in 1907 by Mr. Bickersteth was so successful that in June, 1920, the patient wrote: "I regard myself as being completely cured"—a fact discrediting the idea that operative interference favours recurrence and shortens the life of the patient.

SYMPTOMS AND SIGNS.—A painless, slowly-growing swelling at the angle of the jaw. If *pain* is present, then, microscopically, a superadded inflammation is present. The slow growth is very characteristic, but 7 cases complained of recent sudden increase which evidently caused alarm. In these cases no malignant change had occurred; possibly the capsule had been so thinned as to yield, and liberate the cells from their constrained position beneath—a point I shall refer to in dealing with the pathology of recurrence. The lobule of the ear is early displaced outwards, but meatal obstruction is rare—one case in our series, which was relieved by syringing. Later, redness and ulceration of the skin occur. The lymphatic glands are not enlarged except from other diseases. Facial paralysis is unrecorded except as a post-operative event or with the onset of carcinoma.

TREATMENT.—The situation of these tumours renders operation in any great enlargement a formidable proceeding, and the records show evidences of great difficulties from

the operator's point of view—ligation of the external or internal carotid arteries, or both, with the internal jugular vein or the common carotid artery, had to be performed so frequently in the middle of the operation that ligation of the external carotid should be a useful preliminary in all cases of great enlargement.

The type of incision must vary with the size and position of the tumour. One patient complained of the incision which swings round the jaw half an inch from it—she was evidently troubled with the anæsthesia and hyperæthesia due to division of the branches of the great auricular nerve. An incision described by Ochsner[2] would avoid this complication; the incision commences midway between the lobule of the ear and the angle of the mouth, and swings downwards and gradually backwards to about half an inch below the angle of the jaw.

Seven post-operative cases of facial paralysis occurred, of which 6 have been traced, and with one exception no mention is made of this disfigurement; so that I am forced to believe that the tension relaxation of this nerve by removal of the tumour produces more cases of facial paralysis than the surgeon's knife. No cases of salivary fistula have occurred. Treatment with spirit biniodide, scraping of imperfectly-removed tissue, to express or kill any liberated cells, do not seem to influence recurrence, but are safeguards of great comfort to the operator.

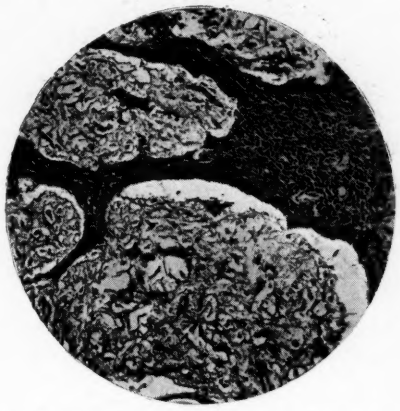

FIG. 72.—Mucinous degeneration of the diffuse type.

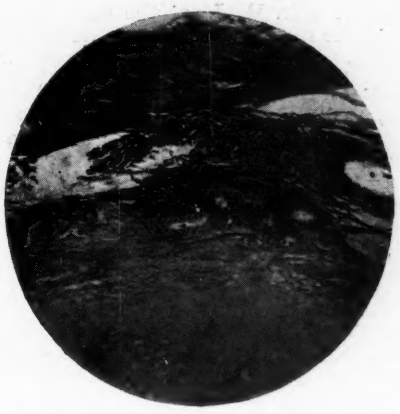

FIG. 73.—Mode of growth and cause of recurrence. Capsule-splitting by healthy cells. Note inflammatory reaction which caused pain.

Recurrence.—Apart from the incomplete removal of very large adenomata and the development of malignancy in a simple tumour (*see* later), recurrence took place in 9 out of 32 cases traced, i.e., 28·1 per cent. Three patients still possess their tumour and hesitate to undergo further operative treatment; 2 are being controlled by radium; 3 recurrent cases (one the lymphangioma) are cured if the five-year limit be accepted; another is alive and well, but within this limit. Immediate recurrence occurred in 5 out of 9 cases in which accurate history is available. Re-operation time averages five years in 11 other cases.

An examination of the sections of 70 cases of adenoma shows that the epithelial cells persist longest either in the extreme centre of the degenerate mass, probably around a blood-vessel; or, what is more important from the surgical point of view, immediately beneath the ever-thinning capsule. Even in the most degenerate tumour, small elongated groups of cells will be detected splitting the layers of the capsule and leading a more healthy existence than in the rest of the tumour.

If the surgeon enucleate the adenoma rather than excise it, he may inadvertently split the capsule, liberate the soft epithelial cells contained between its layers, and run the risk of recurrence unless treatment with cautery or strong antiseptic be employed. This process of capsule-splitting seems to be the method of growth during life, and in *Fig.* 73

we see both recent splitting and resulting inflammatory reaction in the effort to stem the progress of tumour formation. Judd also refers to this in the *Mayo Clinics*, 1910. The figure is from E. M., female, age 48 at time of onset. Two years later a painful tumour, fixed by inflammation, was enucleated, in 1913. By 1920 no recurrence had taken place, and there was 'no disfigurement', for which she is duly grateful to Mr. Bickersteth.

AFTER-HISTORIES OF 32 CASES OF ADENOMA.

Case 1.—Mrs. A. P., age 31. History of mumps [7901]. Tumour noticed, 1911. Typical mixed tumour" removed 1913. Recurrence, removed, 1916. Immediate recurrence, and incomplete operation, August, 1917. "Ordinary type of parotid tumour, apparently not malignant," Oct. 27, 1920. Husband writes operation a complete failure: she is "under treatment of some sort at Carnarvon to lift the tumour and not the roots". Life history of tumour to date, nine years—a surgical failure.

Case 2.—Miss S. J. R. [3357]. Tumour appeared at side at the age of 27, and was excised at Wrexham. Recurred seven years later. Mr. Thomas removed it five years later, Nov. 22, 1917. Reported "quite successful" on May 23, 1920.

Case 3.—Mrs. A. N. [2699]. Age 35 when tumour appeared on right side in 1899. Removed after recent rapid growth, 1915. Report, May 25, 1920, "Very grateful to Mr. Thomas not only for the operation, but for saving my face from being drawn".

Case 4.—Mr. R. J., at the age of 24, noticed tumour with aching pain. Removed, July 29, 1910. Quite a success for a number of years—now as large as ever (due in some mystical way to army life).

Case 5.—Miss N. [1991]. Age 50 at time of operation by Mr. Thomas, December, 1912. Nov. 5, 1920: Quite successful. Mucous adenoma (*see Fig.* 71).

Case 6.—Ellen McT. After 10 years' delay, tumour was removed by Mr. Paul in February, 1906. Dec. 2, 1920: Alive and well.

Case 7.—Kitty C. Noticed tumour at age of 21. Nine years later it was enucleated, Feb. 19, 1907. Feb. 10, 1920: A complete success, thanks to Mr. Paul.

Case 8.—Miss W. [1178]. Age 38 at time of operation by Mr. Thomas on April 30, 1910. Left side. July 5, 1920: Dr. O. Evans reports alive and well.

Case 9.—Miss O. B. [1105]. Age 30 at time of onset. Operation two years later by Mr. Thomas, left side, Feb. 2, 1910. Tumour an inspissated cell-less mass of degenerated tissue. Dr. O. T. Evans reports her alive and well on July 5, 1920.

Case 10.—Rev. G. [648]. Age 50 at time of operation. Enucleated by Mr. Thomas, April 18, 1909. Died in 1915 of angina pectoris. No recurrence. Dr. Arkle.

Case 11.—Mr. J. H. [6753]. Age 64 at time of operation by Mr. Kelly, September, 1915. Complete success, and thanks the operator on Nov. 4, 1920.

Case 12.—Miss M. T. [2776]. At the age of 25, tumour appeared on right side. Came suddenly and was painful. "Remembers straining jaw". Removed three years later by Mr. Thomas in 1915. Writes on May 27, 1920, result "quite satisfactory".

Case 13.—Mr. E. J. Age 23 when operated upon, Nov. 23, 1904, by Mr. Paul, whose pathological diagnosis was adenoma. No trouble since. Dec. 18, 1920: Very grateful to Mr. Paul and infirmary staff. Note: 16 years without recurrence.

Case 14.—Mrs. A. [998].—First operated upon in 1903 at the age of 56. Had a recurrence and was again operated upon in October, 1909, by Mr. Thomas. Dr. Marsden writes, "Now 74 years of age and in the best of health". A pathologist reported cancer in 1909.

Case 15.—Mr. J. E. J. Recurrent tumour removed by Mr. Rushton Parker, Jan. 31, 1907. Nov. 10, 1920: "Successful in every way" for 13 years.

Case 16.—Mrs. M. K. Developed a tumour at age of 31. Removed by Mr. Bickersteth five years later, March 22, 1909. In May, 1920, alive and well.

Case 17.—Mrs. H. [587]. Operated upon by Mr. Thomas on Feb. 11, 1908. Dr. Nixon reports alive and well on June 29, 1920, and adds a useful research note that this had been the only case in his practice.

Case 18.—Miss Jessie T. [3057]. Age 21 at time of operation by Mr. Thomas in December, 1916. Left side. May 14, 1920: Is very glad she had it removed. No recurrence.

Case 19.—Mrs. J. M. [2313]. Tumour appeared at age of 51. Left side. Two years later, on Oct. 1, 1909, it was removed by Mr. Bickersteth. Report on July 18, 1920, says, "Quite all right since the operation".

Case 20.—Mrs. E. M. [4765]. Age 48 at onset; two years later tumour removed by Mr. Bickersteth, in 1913 (*Fig.* 73).

Case 21.—Mr. D. J. [5594]. *Fig.* 72 (*see* text, p. 78).

Case 22.—W. E. [1476]. Age 25 when tumour appeared in 1905. Removed by Mr. Thomas in 1911. Dr. Arthur Walker reports alive and well, July 8, 1920.

Case 23.—M. M. [2951]. Multiple recurrence—tumour still present. In 1911 this patient, at the age of 52, developed a tumour which was removed the same year at West Hartlepool. In 1912 it had recurred and was removed at the Royal Infirmary. In 1914 it recurred again and was removed. In 1919 a recurrence was treated with radium by Dr. Holland. Total duration of the disease is eleven years to date.

Case 24.—Miss A. L. Now married, with children. At the age of 27 had an adenoma removed. It recurred in 1909 and cancer was suspected, but there is no histological evidence of this. Dr. Carse reports that recently it has again recurred, and he is hoping to obtain further surgical treatment.

Case 25.—J. G. [5859]. Trauma fifteen months previously. Tumour removed, April 27, 1914. Recurred, February, 1916. Removed, January, 1917. Recurred; radium prescribed, and said to be cured. Recurred, April, 1919. Attends monthly for radium and has improved sufficiently to seek a higher post; she speaks in generous terms of the treatment.

Case 26.—W. H. Appeared at age of 30—operated upon by Mr. Kelly five years later. Middle of 1920, alive and well.

Case 27.—J. J. [162]. Tumour appeared at age of 31. In January, 1905, tumour was enucleated by Mr. Paul. Fifteen years later, Dec. 10, 1920, was alive and well.

Case 28.—Miss McC. Age 30 at time of operation in 1915. Died 1 year later, cause unknown.

Case 29.—Miss M. B., age 43 at time of operation, Jan. 1, 1917. Alive and well, Nov. 8, 1920.

Case 30.—Miss M. P. T. At age of 20 noticed swelling on right side of face. Enucleated Dec. 3, 1917—eight years later. Alive and well, May, 1920.

Case 31.—Miss M. B., age 13. Operated upon for 'cystic lymphangioma' in 1892. Recurred, and was removed in 1895, and again in 1897. Since then alive and well, 1920. Mr. Rushton Parker.

Case 32.—Miss P. W. [1710]. Age 40 at time of operation by Mr. Thomas. A chronic inflammatory thickening of parotid gland. Excised and cured.

Case 33 (too late for inclusion).—Mr. E. E. Age at onset 71. Operation three years later. Died one year afterwards from 'cystitis'. No recurrence.

Case 34 (too late for inclusion).—Mr. G. E. Age at time of operation 25; tumour removed by Mr. Rushton Parker, 1892. Alive and well, March, 1921.

CARCINOMA.

Of the total 124 cases, 27 (21·8 per cent) were carcinomatous on section. Of these, 5 cases were traced and 2 others are known to have inoperable recurrences. The histological appearances, supported in 4 cases by the clinical history, suggest that carcinoma was engrafted on a simple tumour in 7 out of 20 cases (35 per cent).

Age.—Excluding cases arising as simple adenomata, the average age is 46·4, sixteen years later than the adenoma. The malignant change in adenomata appears to occur about the 38th year. The average operation age is 48·1 years. The delay of 1½ years (5 cases) is less than in simple tumours, but still significant.

Sex.—Again the preponderance of females to males is noticeable—12 to 8.

Trauma occurred in 2 out of 12 histories. One patient played a wind instrument.

Pathology.—Two types can be recognized: (1) *Spheroidal-celled cancer*; (2) *Adenocarcinoma*, in which the cells are more cubical. Of the primary cases, examination of the sections shows 9 spheroidal-celled cancer (*Fig.* 74) and adenocarcinoma (cubical-celled) (*Fig.* 75). Those deemed to arise in simple adenomata show 4 spheroidal-celled cancer and 3 adenocarcinoma (cubical-celled).

Fig. 74.—Mrs. J. R. Patient of Mr. Thomas. Onset at age 49, with pain. Twelve months later the size of a Tangerine orange. Growth encapsuled—removed August, 1917. Recurred in glands. Removed, March, 1918. Again recurred in August, 1918, and glands showed spheroidal-celled cancer. Later history unknown; but no reply to so recent a case is significant.

FIG. 74.—Spheroidal-celled carcinoma.

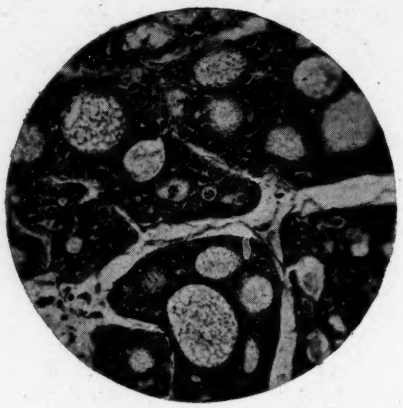

FIG. 75.—Cubical-celled adenocarcinoma.

Fig. 75.—Miss L. B. Age 32 at onset in 1911. Tumour on left side of face adherent to external jugular vein; within one year had caused facial paralysis. Removed by Mr. Thomas in January, 1912. A cubical-celled carcinoma with marked inflammatory reaction. Dr. Pethick writes that growth recurred locally and orbit became involved. Patient died in August, 1917. Radium failed to relieve.

The histological features are the well-defined basal layer, the healthy and highly-organized stroma, the small amount of degeneration (*Fig.* 76: Miss V., age 20; Mr. Paul's case; history unknown), and the more marked inflammatory reaction of the tissues, with direct infiltration of parotid tissue.

FIG. 76.—Spheroidal-celled carcinoma with small areas of mucous degeneration.

SYMPTOMS AND SIGNS.—

1. Rapid growth.
2. Pain at onset or within a few months, in eye or ear in 7 out of 11 cases.
3. Facial paralysis. Four out of 11 cases prior to operation, 3 cases after operation, one of the latter known to have been permanent.
4. Early fixation of tumour; interference with jaw movements; occlusion of external auditory meatus; invasion of the orbit, with subsequent blindness; occlusion of pharynx, depression of palate; ulceration of skin and secondary hæmorrhage in all cases recorded in this small group. Involvement of lymphatic glands is late in occurrence, and often the site of post-operative recurrence.

RESULTS OF TREATMENT.—

Mr. McB.—Died 1 year after last operation. Primarily simple; duration 12 years. (*See Fig.* 78).

Mr. C.—Died 4 years after last operation. Primarily simple; duration 17 years.

Mr. K.—Probably died. Inoperable four years after last operation. Primarily simple; duration 45 years.

Miss F L.—Primarily simple; 3 years' duration. Now 15 months since complete excision by Mr. Litler Jones. Alive and well; no local recurrence; but similar tumour on opposite side has progressed—this was present at time of operation.

Mrs. E. F.—Died 5 years after operation. Primarily simple; duration 10 years.

Mr. C. S.—Inoperable, 2 years after operation. Recurrence. Previous operation 6 years ago.

Miss L. B.—Died 3 years after an operation; total duration 4½ years.

Mr. J. C.—Died 2 years after an operation; duration 4 years.

The average duration of primary cases seems to be about 4 years.

Case Records.

Mrs. E. F.—Age 35 at onset of growth; constant pain in right ear. Five years later Mr. Litler Jones had the unenviable task of an incomplete removal in November, 1912—already the glands were involved. The patient died, writes Dr. Williams, in 1917. (*Fig.* 77.)

Mr. P. McB.—A case of carcinomatous change in a simple tumour. Onset at age of 54. Twelve years later, 1910, recent pain brought patient to the surgeon. The tumour was then 6 in. in diameter, and facial paralysis was present. The common carotid and external and internal jugular veins had to be tied and the sternomastoid divided. (*Fig.* 78).

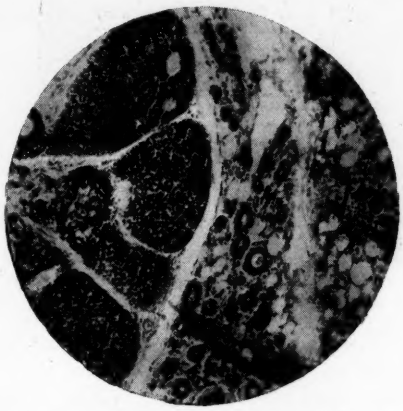

Fig. 77.—Adenocarcinoma in a primarily simple tumour invading parotid tissue.

Fig. 78.—Similar case to *Fig.* 77.

Mr. W. C.—Onset prior to 1891, when patient was operated upon at age of 37. A recurrence took place, and 12 years later a second operation, followed a year later by a third. His son writes that patient passed away in great pain, and the throat had become closed entirely, in 1907.

Mr. W. K.—Onset at the age of 16. Tumour weighing 3 lb. 10 oz—the largest of the series—removed by Mr. Parker 37 years later, in 1900. In 1905 recurrence and removal, again in 1906, declared inoperable in 1908. No reply to inquiries, 1920. Section shows a simple adenoma becoming malignant in 1900.

Miss F. L. [9935].—Age 49 at onset of growth: inflamed for 4 months (painful). Bilateral. Total excision of the tumour on the left side 3 years later, in 1919; that on the right has continued to grow. Left facial paralysis is present (post-operative) Jan. 16, 1921. Section shows large cystadenomata; cartilage and areas of subcapsular round-celled inflammation; but an associated gland showed columnar-celled carcinoma. Total excision by Mr. Litler Jones; so far successful, 15 months after operation.

Mr. C. S.—Age 46 at first operation, 1912. Recurred and removed 4 years later. Recurred and inoperable, August, 1918. No reply from M.O.

Mr. J. C.—Age 61 at onset of swelling in right parotid region: rapid growth, with local pain. Two years later an unsatisfactory removal by Mr. Kelly in January, 1914, Died February, 1916, from the disease. Columnar-celled cancer.

SARCOMATA.

Six cases in 124: 3 females, 2 males, 1 doubtful. Of these, one case only was traced. Ages of patients: 20, 44, 70, 55.

Pathology.—The usual round- or spindle-celled varieties.

Clinical Features.—Sudden pain, facial paralysis, discharge from the ear, difficulty in opening the mouth, pharyngeal obstruction, are recorded.

Radium was used in one case; end-result unknown; patient could not be traced.

A sarcoma, spindle-celled, with alveolar formation, occurred in a patient, J. D., a woman, age 55. After three years it was the size of a walnut, had produced facial paralysis, and involved glands. Total excision with an area of skin by Mr. Thomas in January, 1917, failed ;

FIG. 79.—Alveolar sarcoma ; facial paralysis and involved glands.

FIG. 80.—Same case as *Fig.* 79.

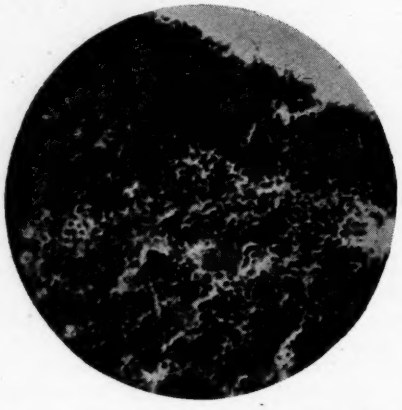

FIG. 81.—Round-celled sarcoma of parotid gland.

the tumour recurred 18 months later. Dr. Porterfield kindly reported that the patient died in 1919. (*Figs.* 79, 80.)

A round-celled sarcoma occurred in a girl, age 20, and was removed by Mr. Jeans in August last. (*Fig.* 81.)

SUBMAXILLARY TUMOURS.

The 13 cases collected did not offer much for investigation ; in only one case was the after-history obtained. On analysis, 8 cases were adenomata, 4 carcinomata (3 spheroidal-celled, 1 cubical-celled), 1 sarcoma. Sex distribution was equal in the simple cases. The average operation age was 35·6 years. One tumour had existed 15 years.

Figs. 82, 83.—Mr. R. H.—Died at the age of 50, 5 months after an operation for carcinoma of the submaxillary gland ; the lymphatic glands were involved at time of operation. At death secondary deposits were present in the lungs. Patient of Dr. J. C. Matthews.

FIG. 82.—Mixed tumour of submaxillary gland, 15 years' duration. Skin scarred by an application of soap and lime.

FIG. 83.—Spheroidal-celled carcinoma of submaxillary gland. Same case as *Fig.* 82.

SUMMARY AND CONCLUSIONS.

1. Of cases operated upon for salivary-gland tumours, 137 have been investigated, and the after-histories of 40 obtained, the majority of which are at least 5 years after the operation.

2. Of these, 124 cases occurred in the parotid and 13 in the submaxillary gland; of the former, the proportion of females to males was 59:19 in simple cases, 12:8 in carcinoma, 3:2 in sarcoma, and about equal in those of submaxillary origin.

3. Of the 124 parotid tumours, 91 (73·4 per cent) were adenomata (this tumour is also called embryoma, endothelioma, and mixed tumour), 27 (21·8 per cent) were cancer, and 6 (4·8 per cent) were sarcoma. Of the cancer cases, 7 out of 20 (35 per cent) arose from degeneration of an adenoma.

4. Two varieties of adenomata were recognized, the diffuse and the acinar; and two varieties of carcinoma, the spheroidal-celled and the cubical-celled (adenocarcinoma).

5. Of the adenomata operated upon over 5 years ago, 15·5 per cent have recurred. Recurrence was immediate in the majority of cases, or under 12 months. It is due to the liberation of healthy cells so frequently seen splitting the capsule in the sections examined. Capsule-splitting with the resultant inflammatory reaction explains the sudden increase in size and pain so often described in the history of the patient.

7. Excision rather than enucleation would diminish the risk of recurrence due to leaving remnants of capsule; and preliminary ligation of the external carotid artery is advisable in any large adenoma or malignant growth.

8. Facial paralysis was not met with prior to operation in the simple cases. Post-operative facial paralysis is more frequently due to tension relaxation of the nerve by removal of the tumour than to nerve section, and is therefore usually temporary.

9. The contention that operation hastens inoperable recurrence, shortens life, or causes disfigurement has no support in this research; and the fact that 35 per cent of cases of carcinoma arise in simple tumours of long standing should serve as a warning to those willing to allow a pre-operative delay of 7 years in primary cases and 5·5 years in recurrent cases.

I wish to thank Professor Ernest Glynn for suggesting this subject for investigation, and for helpful criticisms; Mr. Rushton Parker, Mr. F. T. Paul, and Mr. Thelwall Thomas for material which they willingly placed at my disposal; and those general practitioners who have responded to the call for information without which this paper could not have been written.

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VISITS TO SURGICAL CLINICS AT HOME AND ABROAD.

PLASTIC SURGERY AT THE QUEEN'S HOSPITAL, SIDCUP.

THREE branches of surgery underwent material change during the war: the treatment of fractures, the treatment of wounds of the chest, and the treatment of severe injuries of the face. Fractures of the femur and wounds of the chest had been of frequent occurrence in civil life, but no surgeon had had a large experience of serious facial injuries involving multiple compound fractures of one or both jaws, with hideous destruction of the soft tissues. Every surgeon had performed a few rhinoplasties and had endeavoured to relieve the extensive scarring which had followed burns of the face and neck; but for the most part they had left untouched the deformity caused by syphilis or lupus, and had rarely practised the removal of hairy moles or other congenital malformations which are so often a cause of misery to the self-conscious and unhappy sufferers.

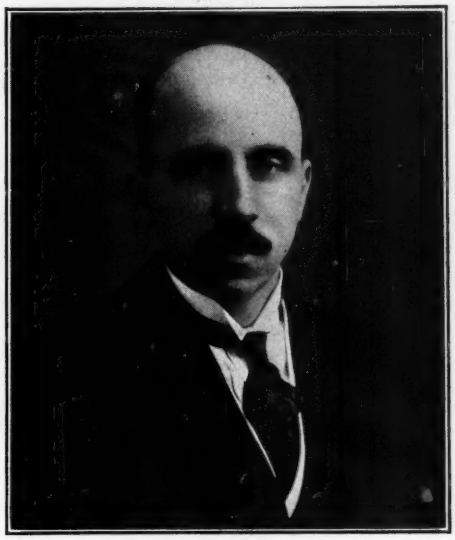

FIG. 84.—Major H. D. Gillies, C.B.E.

Plastic surgery, therefore, was in its infancy at the beginning of the war, and even the general principles of treatment had not been formulated. All, however, was soon changed when severe injuries of the face began to pour into the general hospitals at home, and it became clear that the surgeon and the dentist must work in the closest harmony if any advance was to be made in their treatment.

The experience of ten thousand cases in one hospital alone has now taught what can and what cannot be done by the surgeon working hand in hand with the dentist, and has evolved a special type of surgeon, of dentist, and of anæsthetist—the surgeon infinitely patient and gifted with imagination so that from the very beginning he can foresee the end: the dentist fertile in suggestion and a good mechanician; the anæsthetist such an one as can keep a patient motionless for hours at a time, even when much of the face has been destroyed and the cavity of the mouth is fully exposed. Major H. D. Gillies, C.B.E., proved himself such a surgeon; Captain W. Kelsey Fry, M.C., undertook the dental problems; Captain R. Wade and many others acted as anæsthetists.

The work began in January, 1916, at the Cambridge Hospital, Aldershot, when Major Gillies as surgeon and Captain L. A. B. King as chief dental surgeon determined to advance the treatment of gunshot wounds of the face and jaw. The accommodation was soon found to be inadequate at the Cambridge Hospital, as the number of patients increased, and the results proved to be more and more satisfactory. A well-wooded park (*Fig.* 85) was secured between Sidcup and Chislehurst, in Kent, about twelve miles from London. Special huts (*Fig.* 86) were built in it, with twenty to fifty beds in each. The

hospital was placed on an imperial basis under the command of Lieut.-Colonel J. Colvin, and was one of the hospitals in which the overseas men were treated by their own medical officers. The hospital was quickly filled with a succession of badly-wounded men who could be kept in it for an indefinite period. Major Gillies continued to act as surgeon, with the able co-operation of Major Seccombe Hett, who interested himself more especially in the treatment of injuries of the nose, whilst Captain Kelsey Fry and others devoted themselves to wounds of the jaw.

The continuity of the records of the patients has been a remarkable feature in the work of the hospital. The very complete system of notes is supplemented by drawings, casts, and photographs of the patients in successive stages of the repair of their injuries. The drawings were made by Professor H. Tonks, Slade Professor of Fine Art at the London University, who devoted many months of his time at Aldershot to producing a series of pastel drawings, and his work was afterwards carried on by Mr. Sidney Hornswick. The plaster casts were made by the sculptor, Lieut. J. Edwards, in further illustration of the injuries recorded by the drawings. These casts serve a double purpose, for they not

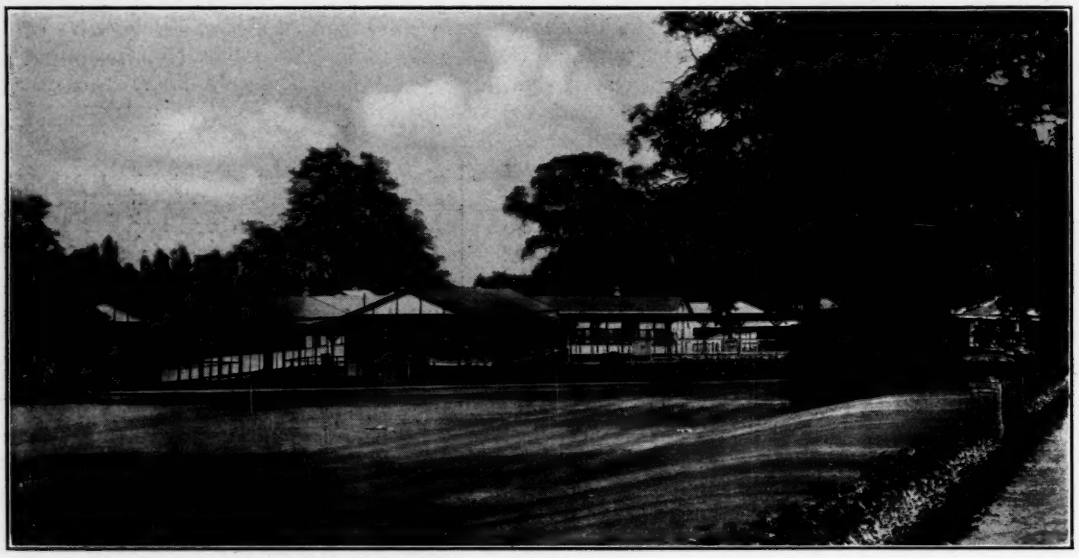

FIG. 85.—The Queen's Hospital, Sidcup.

only show the injuries in various stages of repair, but they can be used to reconstruct the features before the actual surgical operation is undertaken. Captain H. Mulrea Johnston standardized the position for the radiographic records, his work as radiographer being afterwards carried on by Captain R. A. C. Rigby; whilst Mr. Sidney Walbridge produced an excellent series of photographs. These records are so valuable and unique that the greatest care should be taken to preserve them when the hospital is closed. It is desirable that they should be put into the hands of some public body—preferably one which has a library as well as a museum. They illustrate the development and progress of the treatment of facial injuries from its infancy to the present time, and it will be a permanent loss to surgery if they are dispersed or are negligently treated.

Three operations were being carried out in two operating theatres at the time of my visit. Mr. T. P. Kilner was engaged in grafting 4½ in. of the crest of the ilium into a mandible defective to this extent; Mr. Gillies was repairing a mandible where there had been a great loss of the soft tissues as well as of the bone, and Captain Shaw was making a new nose. Each patient had already been operated upon at several different hospitals, and each had been sent to Sidcup for final treatment.

The anæsthetic was given to the patient operated upon by Mr. Gillies and also to Mr. Kilner's patient by Shipway's intratracheal apparatus, the anæsthesia being conducted so smoothly by Dr. McGill and Dr. Rowbotham that the patients remained motionless from 10 a.m. until 1 p.m., and yet when I saw them in the ward at 1.15 both men were well on their way to recovery, and the sister stated that post-anæsthetic vomiting in such cases of prolonged narcosis was rarely severe.

The buccal cavity was completely exposed in the patient upon whom Mr. Gillies operated, as the centre of the mandible had been blown away and there was a corresponding destruction of the soft tissues of the lower lip, so that the under surface of the tongue was completely exposed. The anæsthetic was given intratracheally through a catheter passed along the nostril, whilst a piece of rubber tubing was passed into the opposite nostril to provide a return airway. Ether was employed under positive pressure, and was carried by a stream of air propelled from a small electrically-driven motor.

The principles which govern the practice of plastic surgery at Sidcup are: First, complete asepsis. Secondly, the free exposure of parts—and this often necessitates a return

FIG. 86.—View of the special huts at the Queen's Hospital, Sidcup.

to the original deformity, because all the patients now admitted to the hospital have been previously operated upon elsewhere. Thirdly, repeated operations, each operation being designed to attain some definite step towards the final result. No attempt, therefore, is made to do too much at a single sitting. Fourthly, the formation of long and supple flaps free from scar tissue and with a thoroughly good blood-supply. Lastly, the accurate apposition of skin to mucous membrane, or, when this is impossible, the provision of a lining membrane for all mucous cavities, such lining membrane being usually taken from the skin either in the form of flaps or grafts.

In the case operated upon by Mr. Gillies a flap had been cut from the left side of the chest ten days previously. The flap measured six inches in length and two inches and a half in breadth, and had extended through the entire thickness of the skin and superficial fascia. The free edges of the flap had been brought into apposition, and sutured along their whole length, to form a tube which still remained attached to the general surface of the body at each end. At a second operation the tip of the flap had been detached from the chest and re-attached to the soft tissues on one side of the gap in the mandible. It was intended that this flap should form both the lining membrane of a new lower lip

and the covering epithelium of a new alveolar ridge, so that eventually a full-sized bone-graft might safely be inserted to reconstruct the lost portion of the mandible. During the short period which had elapsed since the dissection of the flap, the edges had united by first intention, and the flap presented itself as a roll of tissue of the size and consistency of a flaccid penis, attached at one end to the margin of the buccal wound, and at the other to the skin of the neck, from which it had not yet been separated. It was lying free in the interval between these two points, and the skin beneath it had healed. The flap was of the same temperature as the surrounding parts, and was evidently well supplied with blood.

The object of the morning's operation was to secure a further attachment of the graft along the floor of the mouth to form a new lining membrane for the lower lip and alveolus which would be made by a subsequent operation. For this purpose the tubular graft was laid open by an incision carried along the whole extent of its free portion, and its edges were sutured to the refreshed surface of the tissues on the under surface of the tongue, care being taken to secure complete hæmostasis. The skin of the neck, including the platysma, was released by incisions carried beneath the upper end of the pedicle to allow the flap to slide forwards and thus relieve any undue tension upon it. These proceedings were sufficient for the time, and nothing more was attempted.

Mr. Kilner was engaged in bridging a 4½-in. gap in the mandible of another patient, whose lower lip was intact. The bed having been prepared for the graft, and the ends of the fractured bone having been refreshed and pierced for the passage of a silver wire, the graft was taken from the crest of the ilium. It was cut with a mallet and chisel, and included the periosteum, the outer compact tissue, and a layer of cancellous tissue ; but the inner table of the bone was not taken. The graft, which had been carefully measured to fit the gap in the mandible, was bevelled at each end, and was partially divided transversely at several points to enable it to retain a curved shape. It was then laid aside in a warm and dry sterilized towel until it was required. When all was ready for its reception it was transferred to the gap ; its ends were perforated with two holes corresponding to those which had been made in the ends of the fractured mandible, and it was wired in place with two silver wires, the periosteal surface being placed externally. The soft tissues were then brought together lightly over the graft.

Mr. Chubb and Mr. Russell, the other two surgeons attached to the hospital, were not seen at work, but it was understood that the principles which guided them were essentially the same as those described above.

Where all have done well it is difficult to single out one for special praise, but Mr. H. D. Gillies has had the longest and most continuous experience, whilst his large and well-illustrated work on *Facial Deformities* shows how seriously he has undertaken the subject and how much he has done to advance it. A New Zealander by birth and education, he has proved himself as good an athlete as he is a surgeon. Born at Dunedin in 1882, the son of Robert Gillies, a member of the House of Representatives, he was captain of the Cricket XI. at Wanganui College, where he received his early education. Coming to England, he rowed in the Cambridge University boat in 1904, and played golf for Cambridge in 1903, 1904, and 1905. He played golf for England *v.* Scotland in 1908, and won the St. George's Grand Challenge Cup in 1903. He received his medical education at St. Bartholomew's Hospital, where he played as first violin in the Hospital Musical Society ; he also sketches in water-colours. It can be no matter of surprise, therefore, that one who has so complete a power of muscular co-ordination should prove himself an adept in the minute work of plastic surgery.

The photographs illustrating this article were taken by Mr. S. Walbridge, the official photographer to the Queen's Hospital, Sidcup.

THE PROGNOSIS OF CARCINOMA MAMMÆ. A REVIEW OF 169 CASES.

By G. PERCIVAL MILLS, Birmingham.

The cases under review were those operated on in the General Hospital, Birmingham, during the years 1910–15, to which have been added, through the kindness of Sir Gilbert Barling, a number of cases from his private practice. The investigation was primarily intended to be pathological, and for this reason those cases alone are included in which I have personally studied microscopical sections of the tumour. I was able to do so in practically all the hospital cases, and in the great majority of the private ones, so they may be considered as fairly representing the period in question. The clinical notes in most of the hospital cases were made by myself specially for the purpose, and in the private cases were made by Sir Gilbert Barling. I was fortunate in having the assistance of Professor Shaw Dunn in making the pathological notes on some of the more difficult cases, and to him I owe my grateful thanks.

The usual difficulty was experienced in selecting any period for a standard of cure, for recurrences may of course take place after almost any interval. They are not common after six years, however, and as all deaths during the six-year period from whatever cause are included as due to carcinoma, the deaths from other causes during this period will about balance the few probable recurrences later. A six-year period has therefore been taken as the standard of cure, and it has the advantage of being about the period since the last of the cases under review was operated on.

The cases were all pathologically carcinoma, and in all but eleven of them a clinical diagnosis of carcinoma was also made before operation. Of the total 169 cases, 129 were in hospital and 40 in private.

In all, only 118 cases were traced up to six years after operation. A system of routine inquiries every six months was interrupted by the war, and many cases were therefore lost sight of from one to three years after operation. A belated inquiry after the war was over usually resulted in the post-office formula, "gone, no address", and these cases were excluded from the statistics. When, however, an envelope was returned marked 'deceased', the case was included and the death presumed to be due to carcinoma.

Of the 118 cases traced, 47, or 39·8 per cent, were living and well at the end of six years; of 87 hospital cases, 32, or 35·5 per cent, were well; of 31 private cases, 15, or 48·4 per cent, were well. This difference is not due entirely to the private cases having been operated on earlier, as is shown by the figures for cases in which the glands were already infected (*vide infra*).

Involvement of Glands.—The next step was to separate the cases into those in which the glands were infected microscopically and those in which they were free, and a word of explanation is necessary before these figures are presented. Certain very striking changes have been described in the lymphatic glands which drain a cancerous area, and are considered by some to be a definite pre-cancerous condition, while regarded by others as a mere chronic inflammation or hyperplasia. While I personally believe that this condition is due to a cancerous invasion in the sense that it is a reaction of endothelial cells to infection, I have not included such cases among those in which the glands were infected. Under the heading 'gland infected' are included only those cases in which a definite epithelial growth was found in the glands. Doubtful cases have been classed as negative.

GLAND-INFECTED CASES.—

Of 71 gland-infected cases, 13, or 18·3 per cent, were well in six years.
„ 56 hospital cases, 7, or 12·5 „ „ „
„ 15 private cases, 6, or 40 „ „ „

This very striking difference between hospital and private cases is probably due in part to the more frequent use of prophylactic irradiation in the latter. Of the cases which died under six years, the average duration of life was in hospital cases twenty months, in private twenty-five months. Here the difference is easily explained by the better social condition of the patients and the more frequent use of irradiation.

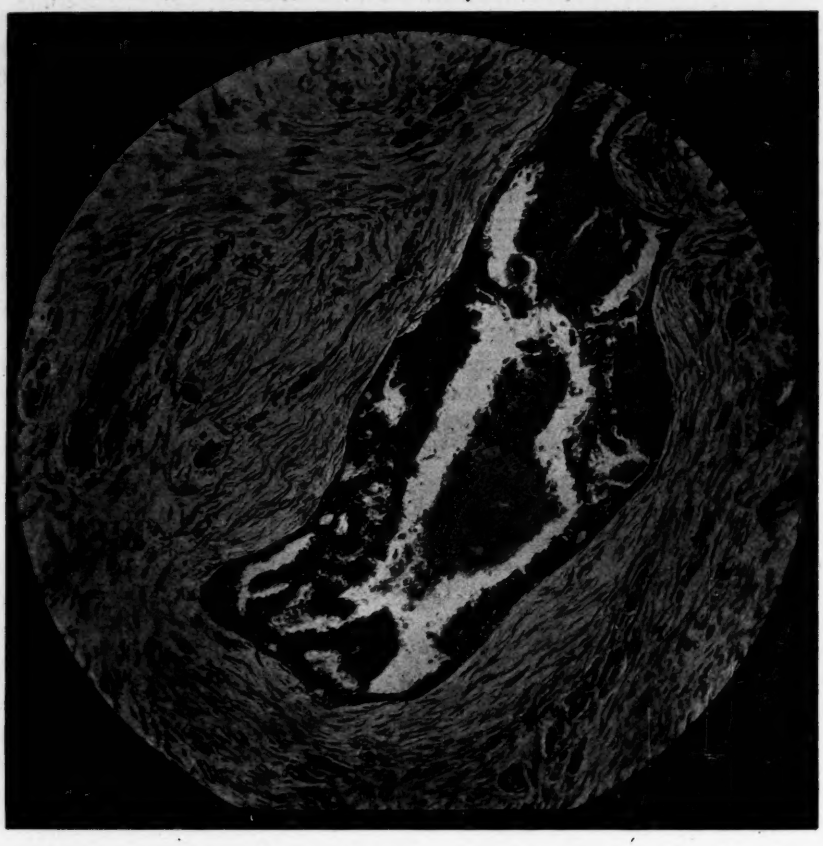

FIG. 87.—Tumour classified as ' carcinoma simplex plus duct changes '. Note overgrowth of duct epithelium. Most of the section showed a typical scirrhus.

GLAND-NEGATIVE CASES.—

Of 54 cases, 34, or 62·9 per cent, were well in six years. This must be regarded as a very satisfactory figure. For hospital cases the figure was 65·8 per cent, and for private cases 56·2 per cent.

The average duration of life in cases not living six years was in hospital cases twenty-eight months, and in private cases thirty-three months. The relatively small number of private cases prevents much being made of a small difference in percentage, but the increased longevity of fatal cases in private is again notable.

Pathological Classification.—Primarily it was intended that this inquiry should be almost entirely pathological. I had been so impressed with the very variable behaviour as regards the recurrence of tumours clinically similar in character and extent, that I hoped a careful microscopical study would reveal differences on which a logical prognosis

might be based. It soon became evident, however, that most of the distinctions I had hoped to make, such as 'degree of fibrosis', 'size and arrangement of cells', 'leucocyte infiltration', etc., concerned characters which varied infinitely in different parts of one and the same tumour. Consequently it was only possible to distinguish here and there some exceptional character in certain tumours, and to work out the prognosis separately for these cases, to see if it were better or worse than the average. The occurrence of squamous metaplasia, for example, was studied in this way, but found not to affect the prognosis.

FIG. 88.—'Squamoid' tumour. Note the massive alveoli of polymorphic cells fitting closely to the stroma, and the central degeneration in each alveolus. In this case the peripheral cells tend to be columnar.

Finally, the tumours were grouped into four classes as follows :—

1. *Typical carcinoma simplex*, or spheroidal-celled carcinoma, whatever the degree of fibrosis, and whether columnar or squamous metaplasia was present or not. Of this type there were 88 cases.

2. *Carcinoma simplex plus duct changes.* A similar tumour to *Class* 1 ; it contained in addition numerous dilated ducts showing definite and frequent epithelial overgrowth. Of this there were 14 cases (*Fig.* 87).

3. *Papillary carcinoma* showing definite local infiltration. Of this there were 4 cases.

4. A peculiar tumour which, on the suggestion of Professor Shaw Dunn, I have called a 'squamoid'. It consists of very large alveoli of polygonal cells with large nuclei ; the cells at the periphery of the alveoli are flattened and fit closely to the stroma, giving the tumour the appearance of a squamous carcinoma. There are, however, no prickles and no cell-nests. A characteristic feature of the tumour is the regularity with which degener-

ation occurs in the centre of each large alveolus, resulting in large rings of tumour-cells. In older parts of the tumour these rings coalesce and give rise to curious serpigenous bands of tumour-cells. Clinically these tumours are hard, slow-growing, and usually firmly attached to the skin (*Figs.* 88 and 89). Of this tumour there were 10 cases.

Of the 88 cases of *Class* 1 (carcinoma simplex), 29, or 32·9 per cent, were well in six years; i.e., about 6 per cent less than the average for all cases.

Of the 14 cases of *Class* 2 (carcinoma simplex plus duct changes), 8, or 57·1 per cent, were well in six years.

Of the 4 cases in *Class* 3 (papillary carcinoma), all were well in six years.

Of the 10 cases in *Class* 4 (squamoid), 4, or 40 per cent, were well in six years.

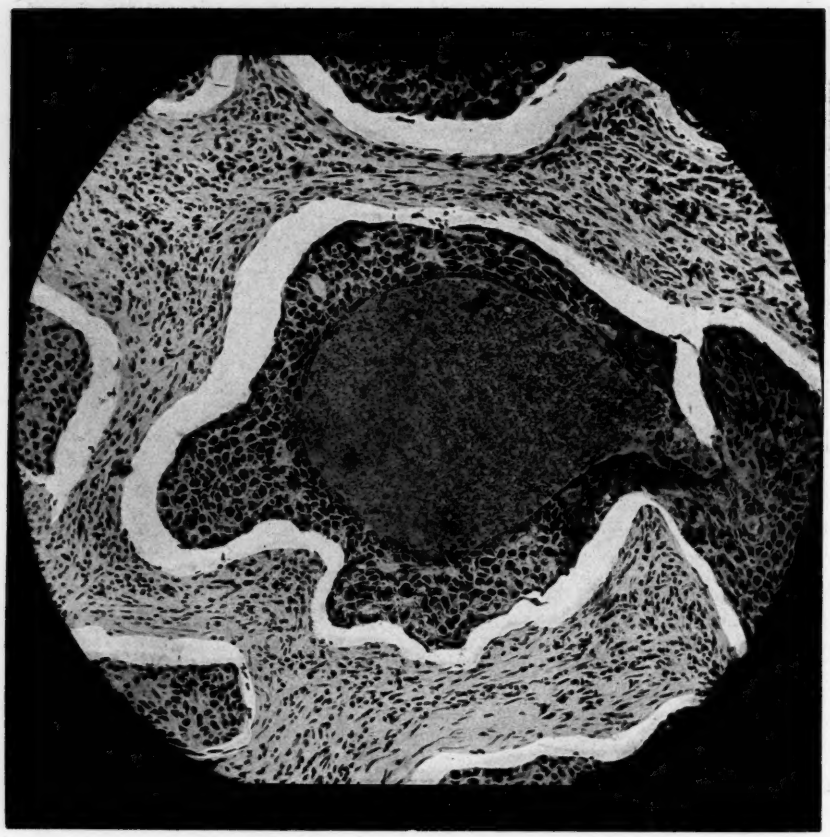

FIG. 89.—Another example of a 'squamoid'. The tumour cells have shrunk away from the stroma, and the peripheral cells are definitely flattened.

The prognosis is therefore worst for typical carcinoma (32·9 per cent), better for a squamoid (40 per cent), better still for a carcinoma with duct changes (57·1 per cent), and very good for papillary carcinoma. At first sight it would appear that to distinguish cases with this epithelial overgrowth of ducts as a separate class is entirely artificial, and it is certainly very doubtful if they are pathologically a different type of tumour. In examining large numbers of sections, however, it was noticed that this overgrowth of duct epithelium was present in a certain small proportion, and the figures for these cases were worked out separately, with the results stated above. It should be made clear, perhaps, that these were not clinically cases of 'duct carcinoma'; they were clinically carcinoma of the common type, and it was only on microscopical examination that the duct changes

were noted. An explanation suggested by the recent work of Sir Lenthal Cheatle is that the majority of breast carcinomata start as an overgrowth of duct epithelium, and that as the tumour grows by infiltrating the periductal tissues, the original ducts are crushed out of all recognition. Consequently, in only a comparatively early case are these pathological ducts visible, and in an early case the prognosis is, of course, better. In other words, the presence of these ducts in a section does not indicate any special type of tumour, but merely that we are dealing with an early case. Whatever be the explanation, the figures appear to show that when these ducts are present the prognosis is about 24 per cent better than in their absence.

Nor is it possible to regard the 'squamoid' as a definite pathological entity, for though its typical appearance is utterly different from that of an ordinary carcinoma, there have been cases (two) in which a section from one part of a tumour has been a squamoid and from another a carcinoma simplex. Moreover, there are intermediate cases, and in some—where the primary growth has been difficult to classify—the secondary growths have been squamoids. In a typical squamoid, however, there is nowhere the appearance of carcinoma simplex, and only such cases are included under this heading.

Clinical Enlargement of Glands.—The importance of the pathological involvement of glands raises the question of the prognostic value of their clinical enlargement. In the first place it is necessary to determine in what proportion of cases with clinical enlargement of glands pathological infection has already taken place. Of 50 cases with clinical enlargement of axillary glands, 30 were infected and 20 were free. This represents an error of 40 per cent, which renders clinical enlargement of axillary glands a sign of uncertain prognostic value. Conversely, of 23 cases in which no glands could be felt, 11 were infected and 12 free. One is accustomed to attach great importance to the hardness of enlarged axillary glands in carcinoma, but in this series, out of 25 cases with hard axillary glands, there were 9 not infected. Clearly, therefore, we can expect only a rough accuracy in estimating the prognosis according to this factor. The actual figures are :—

Glands clinically absent, 19 cases ; 9, or 46·2 per cent, were well in six years. Glands clinically enlarged, 50 cases : 16, or 32 per cent, were well in six years. Glands enlarged and hard, 25 cases : 6, or 24 per cent, were well in six years.

Age of Patient at Operation.—This factor has proved of less importance than was expected, probably because any death within six years of operation was regarded as due to carcinoma. If age has any effect in improving the prognosis, it is evidently counterbalanced by the greater natural death-rate for the later periods of life.

Of cases with non-infected glands who were well in six years, the average age at operation was 49½ years.

Of cases with non-infected glands who died under six years, the average age at operation was 48½ years.

Of cases with infected glands who were well in six years, the average age at operation was 50 years.

Of cases with infected glands who died under six years, the average age at operation was 48½ years.

The differences, of course, are negligible, and it would appear that the importance of age has been exaggerated.

Duration of Growth before Operation.—Average duration of growth in 32 cases well in six years was 9 months. Average duration of growth in 55 cases dead under six years was 9 months. The figures give no help to prognosis. Obviously there are two factors in the case, which neutralize each other. The slow-growing, relatively benign tumour is left a long time before complaint is made, whereas the rapidly-growing very malignant tumour attracts attention early.

Adhesion to Skin.—Of 76 cases of tumour adherent to the skin, there were alive and well in six years 29, or 38·1 per cent.

Of 29 cases of tumour not adherent to the skin, there were alive and well in six years 12, or 41·3 per cent.

The figure for adherent cases is only a trifle below the average for all cases (39·8 per cent), while that for non-adherent cases is about the same amount above it. Adhesion to skin therefore makes little difference to prognosis. There are again probably two factors at work here, for though adhesion to skin is, *per se*, a bad sign, its early occurrence may indicate that the growth was in a superficial part of the breast, and that adhesion to muscle, a much more serious sign, would occur late.

Adhesion to Muscle.—Of 32 cases of tumour adherent clinically to the pectoral muscle, there were alive and well in six years 7, or 21·8 per cent.

Of 66 cases of tumour not clinically adherent to the pectoral muscle, there were alive and well in six years 34, or 51·5 per cent. As one would expect, the prognostic importance of adhesion to the muscles is clearly brought out.

Obesity.—It is a common belief that the prognosis in obese patients is much worse than the average, and that it is best in rather spare people. Unfortunately, it was only rather late in the inquiry that I began investigating this point, and consequently the figures are rather meagre. They are, however, very suggestive.

In 18 cases I have described the patient as 'obese' or 'rather obese', in 9 as 'normal', and in 5 as 'spare'.

Of the 18 obese patients, 2, or 11·1 per cent, are well in six years.
Of the 9 normal patients, 6, or 66·6 per cent, are well in six years.
Of the 5 spare patients, 1, or 20 per cent, is well in six years.

The figures, though very small, show clearly that obesity is a bad sign, and suggest that spare people do not do so well as the normally fat.

General Clinical Considerations.—It remains to be seen, after considering these individual factors, how far general clinical considerations can guide us in making a prognosis. For this purpose the cases were divided into two classes, according to the favourable or unfavourable clinical condition before operation. Cases with a small growth, not adherent to muscle, and with slight or no enlargement of axillary glands, were classed as favourable, as were also cases which were clinically duct carcinoma. A few were omitted owing to imperfect notes. Of 30 favourable cases, 19, or 63·3 per cent, were alive in six years. Of 51 unfavourable cases, 9, or 17·6 per cent, were alive in six years. It is clear, therefore, that clinical considerations are a valuable guide to prognosis before operation, but that a final prognosis can only be made after microscopical examination of the glands.

Nature of Operation Performed.—For statistical purposes the various operations must be classified into a few main types, and, in fact, they fall naturally into three classes:

1. *Sampson Handley's operation.*
2. *Halstead's operation*, under which heading are included all cases in which the underlying muscles were removed but in which no effort was made to remove a very extensive area of deep fascia.
3. *An admittedly imperfect operation*, performed in certain cases on account of the bad condition of the patient, and occasionally for other reasons.

The gland-infected and gland-free cases are considered separately on account of their very different results.

Cases with Glands not Infected.—

1. *Sampson Handley's operation*:
   16 cases; 11, or 68·7 per cent, were well in six years.
2. *Halstead's operation*:
   23 cases; 14, or 60·8 per cent, were well in six years.
3. *Imperfect operation*:
   14 cases; 9, or 64·3 per cent, were well in six years.

The figures for the first two classes are much as one would expect, but those for the third are really startling, and certainly demand a closer analysis of the cases. On looking

through the cards of these cases, one is at once struck by the fact that there was something distinctly unusual in the clinical signs or pathological findings in nearly every one. To make this clear it is necessary to consider them briefly in detail.

CASES OF RECOVERY AFTER INCOMPLETE OPERATION.

Case 1.—M. A. A., age 36. One year's history of lump in right breast. In upper and outer quadrant of right mamma was a hard lump the size of a Brazil nut, feeling like a mass of chronic mastitis. A small, hard mass low down in axilla. Breast and one gland only removed. The lump consisted to the naked eye of a typical patch of chronic mastitis, within which was a brownish lump of a uniform, hard consistence. Microscopically it was a papillary carcinoma. Patient is well ten years later.

Case 2.—F. D., age 42. Eleven months history of a sore nipple with discharge. Induration round nipple, with nodules on the nipple itself. No glands. Breast and axillary glands were removed. Pathologically a papillary carcinoma. Patient well six and a half years later.

Case 3.—J. D., age 56. Lump in the left breast for twenty years ; for six months it had been growing rapidly. A very obese woman with large breasts. In the upper and outer quadrant of left mamma was a stony-hard knobby lump the size of a fœtal head. Just becoming fixed to skin, free from muscles. " Partially fixed in breast, but more movable than a carcinoma." Breast, pectoral fascia, and axillary glands removed. Microscopically, the major part of the growth was a cystic fibro-adenoma, but in one part the matrix appeared to be sarcomatous. Professor Shaw Dunn pointed out to me, however, that in another part there was a definite carcinoma. Patient was well in eight years.

Case 4.—M. M., age 74. A senile carcinoma. Breast, pectoral fascia, and axillary glands removed. Pathologically, carcinoma simplex. Patient died of senility eight years later.

Cases 5, 6, and 7.—These were clinically and microscopically early scirrhus. Breast, pectoral fascia, and axillary glands were removed. They are well twelve, seven, and six years later respectively.

Case 8.—C. R., age 43. Lump in left breast for four months. The rather imperfect notes say there was " a nodular carcinoma the size of an orange in the left breast". Breast, pectoral fascia, and axillary glands were removed. Microscopically a squamoid. Patient was well seven and a half years later.

Case 9.—E. H., age 45. A painless lump in right breast for six months. Rather obese woman. In the upper and outer quadrant of right mamma was a rather soft, rounded tumour the size of a golf ball. Very firmly fixed in breast. Just adherent to the skin and to the outer part of pectoral muscle. No glands in axilla. No evidence of chronic mastitis. A needle withdrew clear fluid, but lump did not disappear. The surgeon in charge regarded it as simple, and removed it locally—I frankly admit, to my own intense disgust. Microscopically the tumour was a carcinoma showing squamous metaplasia and very marked early degeneration of the tumour cells. In view of the after-history of the case, I showed this section to Professor Shaw Dunn, who described it as " a very malignant carcinoma ". Patient is alive and well nine years later.

On reviewing these cases in detail, one sees that the good results obtained are misleading, because evidently the incomplete operations were frequently done on account of the very early or doubtful malignancy of the case. Two were duct carcinomata ; one a cystadenoma just become malignant ; one a senile carcinoma ; and three very early carcinomata. Only in the last two is the result very surprising, and *Case* 9 must obviously be looked on as altogether abnormal. Admitting, therefore, that the results do not justify incomplete operations as a routine, they do show that in early cases, when for any reason a complete operation is unsafe, an incomplete one may be undertaken with a fair prospect of cure.

CASES WITH GLANDS INFECTED.—

1. *Sampson Handley's operation* :
   21 cases ; 4, or 19 per cent, were well in six years.
2. *Halstead's operation* :
   33 cases ; 6, or 18·2 per cent, were well in six years.
3. *Imperfect operation* :
   5 cases ; 1, or 20 per cent, was well in six years.

These figures do not show a great superiority in the results of removing a wide area or deep fascia. Those for the imperfect operations are too small to be of value. Yet

the single case that lived six years was an advanced one with hard glands in the axilla and œdema of the arm. The patient might possibly have had a late recurrence, however. She died of acute bronchitis after a very short illness six years after operation, and her doctor informs me that there was then no sign of recurrence.

SUMMARY AND CONCLUSIONS.

1. Taking a six-year standard of cure, the results of a representative series of cases of carcinoma mammæ operated on by various surgeons are as follows :—

   a. All cases, 39·8 per cent cured.

   b. Gland-infected cases, 18·3 per cent cured.

   c. Gland-free cases, 62·9 per cent cured.

2. The prognosis is worst for carcinoma simplex (32·9 per cent), better for a 'squamoid' (40 per cent), better still for a carcinoma simplex with overgrowth of duct epithelium (57·1 per cent), and very good for papillary carcinoma (100 per cent).

3. Clinical enlargement of axillary glands, even if hard, is no proof of their pathological involvement, nor is absence of clinical enlargement proof of their freedom from involvement.

4. Age at operation, duration of growth, and adhesion to the skin, have little effect on the prognosis.

5. Adhesion to muscle is a bad sign in the prognosis, the difference in the percentage of cures between adherent and free cases being nearly 30.

6. The prognosis is much the best in people of normal fatness ; it is very bad in the obese, and probably bad in spare patients.

7. Of individual operations, one on the lines laid down by Sampson Handley gives the best results, especially in gland-free cases, but is very closely followed by Halstead's operation. Early gland-free cases, however, do extremely well after removal of the breast, pectoral fascia, and axillary glands.

8. Occasionally even an advanced carcinoma will do unexpectedly well after an admittedly imperfect operation.

Finally, I wish to express my thanks to the surgical staff of the General Hospital, Birmingham, for permission to publish these cases, and to Sir Gilbert Barling for kindly allowing me to investigate his private ones.

A CASE OF UNILATERAL POLYCYSTIC DISEASE OF THE KIDNEY IN A CHILD, AGE TWO YEARS.

By ANDREW FULLERTON, Belfast.

S. C.. male, age 2 years, was brought to the Belfast Hospital for Sick Children on February 24, 1920. Three months previously he had passed, during one day only, dark-brown urine free from clots. Six weeks later he developed whooping-cough, and about this time his mother noticed a lump in his right loin which was small at first but became larger. On examination, the child was found to be suffering from whooping-cough. He was thin and anæmic. A swelling about the size and shape of a small melon was felt in the right lumbar region in front. This was fairly movable, firm and elastic, and the abdominal wall could be pushed in between it and the liver. The swelling was dull on percussion except internally, where bowel could be seen crossing it in a longitudinal direction. There was a slight degree of hypospadias, the opening of the urethra being situated on the under surface of the glans at the level of the corona. A right bubonocele was also discovered. The patient was not at this time fit for operation, and was sent home until he had recovered from whooping-cough.

On May 11, nearly three months later, he was again brought for examination. He now looked much better, his colour had improved, and his cough had gone. Under an anæsthetic an attempt was made to pass a child's cystoscope, but the latter could not be introduced along the narrow urethra. Accordingly a small dilator was passed, and a median incision was made into the urethra from the perineum, through which a cystoscope was easily passed. A smooth, mud-coloured, oval calculus about the size of a large cherry-stone was seen lying free on the posterior bladder-wall. There was some cystitis, but the vessels, though blurred, were visible. The ureteral orifices were normal and their efflux clear. While under the anæsthetic, the left kidney could be felt, normal in position and size. After removal of the cystoscope, the stone could be felt bimanually. It would have been a simple matter to have crushed and removed the stone at this sitting, but unfortunately a suitable lithotrite was not available. A specimen of urine, withdrawn from the bladder through the cystoscope, was slightly cloudy, acid, had a specific gravity of 1010, and contained a small amount of albumin. Microscopically, some pus-cells, some epithelial cells from the bladder, and a few red blood-corpuscles were seen.

The diagnosis seemed to lie between sarcoma and cyst, and the former was ruled out because the tumour had not increased in size in the three months that had elapsed between the first visit and the second. Congenital cystic kidney of the usual type was thought to be unlikely, as the other kidney could be felt to be normal in size and shape. Congenital hydronephrosis was negatived by the patency of the right ureter as demonstrated by cystoscopy. A final diagnosis of some form of cyst was made, and operation was decided on. The perineal wound rapidly healed, having leaked for a few days only.

Operation.—This was carried out on May 18, 1920. A transverse abdominal incision was made over the most prominent part of the tumour, and the abdomen was opened. The peritoneum was also divided transversely over the kidney, and the latter was easily shelled out and removed after ligature of the vessels and ureter. On removal, the tumour was seen to be a large cystic mass, with yellowish-white, translucent wall, growing from the upper pole of the kidney, part of which was prolonged up over the lower end of the tumour on its posterior surface. The ureter appeared to be normal. The remainder of

the kidney was normal to the naked eye. The specimen, which weighed 1½ lb., was placed intact in Kaiserling solution. As the condition of the patient caused some anxiety, the removal of the calculus was postponed. Healing took place by first intention.

On June 1 the calculus was removed by suprapubic cystotomy, and the bladder was immediately closed. The abdominal wound was sutured in layers, leaving a small aperture for the insertion of a drainage tube into the space of Retzius.

Description of Specimen (*Fig.* 90).—The following is a short description of the specimen after hardening in Kaiserling. The upper pole of the kidney is replaced by a large globular sac, 10 cm. by 9 cm. This, on section, is seen to consist of a number of cysts, for the most part completely separated from one another. Two of the cysts are of large size and form the main part of the tumour. The cysts vary in size from that of a hemp-seed to that of a small orange. The wall of the main sac is thin and translucent in parts. Elsewhere it is thicker, and partly composed of flattened cysts. The medium-sized cysts are somewhat angular in shape, and their walls are thin and delicate. The pelvis of the kidney at its upper half seems to form part of one of the cysts and to be lined by a similar membrane. This part of the pelvis is dilated, and the uppermost calix is distended. A solid bud projects into one of the upper calices. The large cysts contain clear fluid of a greenish tinge; in some of the cysts the contents are jelly-like and quite green in colour; in others blood-clot is seen. Professor Symmers made a microscopical examination of the specimen, and reports as follows: "Main part of kidney, normal. In the immediate neighbourhood of the fibrous wall of cyst the contiguous portion of kidney showed Malpighian capsules small and atrophied; renal tubules, scarcely recognizable as such, being compressed laterally and scarcely showing any lumen. The epithelial cells lining the tubules are small and granular. The outer wall of cyst is composed of compact fibrous tissue with a somewhat fenestrated appearance, owing to numerous small clefts between the bundles of fibrous tissue. Abutting on the lumen of cyst the fibrous tissue is much more loose, less dense, and lined by some indistinct flattened cells. The septa are thinner, but show a similar arrangement."

FIG. 90.—Polycystic disease of kidney.

Contents of Cyst.—Owing to the presence of formalin in the Kaiserling fluid it was found impossible to obtain a satisfactory examination of the contents of the cyst. Dr. John Milroy, of the Physiological Department of Queen's University, and Mr. Harold Totton, analytical chemist, did what was possible, but were dissatisfied with their results.

Dr. Milroy reports that the contents of the cyst are greenish in colour, but show no absorption bands. The pigment remains in the aqueous layer after the fluid has been extracted with amyl alcohol both in neutral solution and after acidification with dilute

acetic acid. The contents of the cyst are partly gelatinous in character, and their consistence suggests the presence of mucin. On heating, only a small amount of coagulable protein separates out. This result may, however, be due largely to the action of the formaldehyde used for fixation. On acidifying the solution with acetic acid a dense precipitate of protein was thrown down. This was filtered off, washed repeatedly with alcohol to remove the formaldehyde, and then boiled for four hours with normal hydrochloric acid. The resulting solution after neutralization reduced Trommer and Fehling's solutions only slightly. The latter result indicates that only small quantities of glycoproteins or true mucins are present. Part of the protein was precipitated with acetic acid, filtered off, washed with hot dilute acetic acid, and then repeatedly with hot alcohol to remove inorganic phosphates and phospholipins. The residue, after incineration with sulphuric and nitric acids (Neumann's method), gave a precipitate of ammonium phosphomolybdate. Part of the precipitate, therefore, consists of a phospho- or nucleoprotein.

Mr. Harold Totton reports that the sample supplied to him is partly liquid and partly jellified. The jelly consists of protein matter rendered insoluble by the action of the formalin. He extracted some of it with hydrochloric acid to see if any oxalates or phosphates were present, but could find none. The separated liquid portion of the sample still contained protein matter, evidently protein not acted on by the formalin. The liquid contained no oxalates or phosphates. The formalin present would interact with urea, if originally present, and a trace of uric acid in such a mixture would be very difficult to detect.

Composition of the Stone.—Dr. Milroy examined the stone, and reports as follows: "The following constituents are only present in traces: calcium, magnesium, oxalic and phosphoric acids. Xanthine and cystine are absent. The stone leaves little ash on incineration, and consists almost entirely of uric acid. In the centre of the stone there is a small amount of fibrous material, probably of a protein nature."

Classification of Cysts of the Kidney.—Henry Morris[1] classifies cysts of the kidney as follows:—

1. The small and numerous cysts which occur in granular kidneys, and which are of pathological rather than clinical importance.
2. Dermoid cysts.
3. Simple cysts.
4. Conglomerate cysts, polycystic disease, or cystic metamorphosis of the kidney.
5. Hydatid cysts.
6. Paranephric cysts, or cysts which are external to the capsule and formed in the circumrenal fatty tissue, but which are intimately adherent to the kidney, and sometimes communicate with the renal cavity.

The specimen here described would appear to come under the fourth heading. Conglomerate cysts, polycystic disease, and cystic metamorphosis of the kidney are names which indicate a condition which is now generally described as congenital cystic kidney. This disease is almost always bilateral. Morris[1] quotes several authors in support of this. Dickinson found only one case out of 26 in which the disease was confined to one kidney. Lejars, out of 62 cases in the adult, found only one case which was unilateral, and in that case there was a round cystic space the size of a penny piece in the cortical substance of the other kidney. Ritchie states that in post-mortem examination of 88 cases both kidneys were found polycystic in all but two. In this disease the whole kidney is generally affected, and a large number of cysts replace medullary and cortical portions alike, and project on the surface of the organ. Bland Sutton,[2] however, says that there is reason to believe that the cystic change may be limited to a part of the kidney, and quotes in support of this a case described by Edmunds[3]. This case will be referred to later.

A photograph and description of my specimen were sent to Professor Shattock at the Royal College of Surgeons in London, and he informs me that "the only localized polycystic tumour of the human kidney of which the specimen is mounted and preserved is one in St. Thomas's Medical School Museum. This is figured and shortly described

by Mr. Walter Edmunds in the *Transactions of the Pathological Society of London*, vol. xliii ".

Edmunds' specimen was removed during life from a girl, age 18. Projecting from the anterior surface of the kidney there was a globular tumour about 2½ in. in diameter. The tumour was enclosed in a separate capsule, and was found to consist entirely of cysts of various sizes, the largest being about 1 in. in diameter. The cysts contained a thin colourless fluid, and on microscopical examination were found to be lined with an epithelium, in some places columnar, in some cubical. Kretschmer,[4] in a recent paper dealing with solitary and multiple cysts, gives an account of a case investigated by him. This case and the cases in the literature reviewed by him would come under the heading of simple cysts in Morris's[1] classification, and not under that of conglomerate cysts.

It is therefore evident that the case under review represents a type of cystic kidney of great rarity. I have had the advice of several pathologists as to the classification of the specimen, and the balance of opinion appears to be that the case is one of localized unilateral congenital cystic kidney.

I should like to express my grateful thanks to Professor Shattock, of London, Mr. Charles Powell White, of Manchester, Professor Symmers, Mr. John Milroy, and Mr. Harold Totton, of Belfast, for their assistance in examining the specimen and photographs, and to Professor Walmsley for photographs taken in the Anatomical Department of Queen's University, Belfast.

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CONGENITAL OCCLUSION OF THE ILEUM.

By JOHN MORLEY, Manchester.

The problems in antenatal pathology connected with congenital malformations of the small intestine are so varied, and at present so obscure, that it is not desirable that any cases which might throw light on the subject, or even add to the data available, should go unrecorded; and the recent occurrence in my own practice of two cases of congenital occlusion of the lower ileum leads me to submit the following description of them.

Case 1.—**Congenital Occlusion of the Ileocæcal Valve.**

A female infant, 2½ days old, was admitted to St. Mary's Hospital under my care, Nov. 5, 1919, with a history that it had passed no meconium per rectum since birth, and that on the morning of admission it had begun to vomit meconium. The baby had been taken to a general practitioner for the first time on the morning of admission. He gave a simple enema without result, and then sent the child to hospital.

Family History.—There had been three other children in the family. Of these the first two were boys, and were normal and in good health. The third child was a girl, and had died on the fourth day after birth with symptoms exactly resembling those in the present case. No post-mortem examination had been made.

On Admission.—The infant weighed 6½ lb. It was fairly well nourished, but the eyes were sunken and the fontanelle depressed. The abdomen was greatly distended, and coils of small intestine, much dilated, were visible through the abdominal wall in active peristalsis. The child was vomiting dark-green material at frequent intervals. The anus and external genitalia were normal on inspection. On digital examination the finger passed through the anal canal into a patent but very small rectum. Before my arrival the house surgeon had passed up the rectum a series of uterine bougies, but no meconium had come away.

Fig. 91.—Abdominal viscera removed post mortem from *Case* 1. Most of the small intestine has been removed. **I**, Lower ileum. **S**, Stomach. **C**, Descending colon. **L**, Liver.

Operation.—The same evening, after a preliminary subcutaneous saline infusion, the abdomen was opened through the left rectus muscle. Coils of greatly distended and hypertrophied ileum presented. The greatest distention of the ileum with soft meconium was about 18 inches above the ileocæcal valve. In its lower 18 inches the ileum was firmly contracted on to a mass of inspissated contents of the consistency of wet putty. The ileocæcal valve lay rather high up in the right abdomen, and the cæcum and the whole of the colon were quite empty and contracted down to a remarkably small calibre. The saccules of the colon were perfectly developed, and the appendix had not the infantile apical position on the cæcum. The peritoneum contained a little blood, which came from a tear in the wall of the upper rectum produced by the attempt to dilate it with uterine bougies. On account of this injury to the rectum it was decided not to make an enterostomy on the anterior abdominal wall, but to draw the divided ileum down through the anal canal, in the hope of preserving sphincteric control should recovery ensue. Accordingly, the most distended coil of ileum was crushed, ligated, and divided. The distal end was invaginated by a purse-string suture, and the proximal end first emptied into a bowl and then temporarily ligated. Curved dressing-forceps were next passed up through the anal canal into the peritoneal cavity, dilating the rent already made in the upper rectum, and the proximal end of the divided

ileum was brought down outside the anus, and sutured into position with catgut. The abdomen was then closed. The child stood this rather severe procedure badly, and died some six hours later.

Post-mortem Examination (*Fig.* 91).—The whole colon was perfectly formed and fully rotated, but entirely empty of contents other than a little colourless solid mucus, and its average external diameter was only 6 mm. The peritoneal relations of the colon were normal, i.e., there was no persistence of ascending or descending mesocolon. The cæcum had not fully descended to the right iliac fossa. The rectum had been almost torn across at its junction with the pelvic colon, where the ileum had been drawn down to the anus.

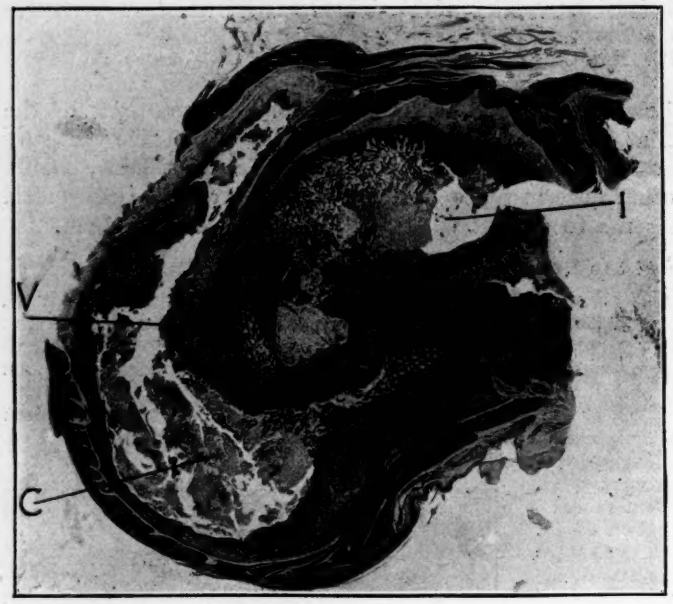

Fig. 92.—Low magnification microphotograph of section through centre of occluded ileocæcal valve in *Case* 1. I, Lumen of ileum. C, Lumen of cæcum. V, Upper segment of ileocæcal valve.

On opening the ileum just above the ileocæcal valve and clearing out the thick inspissated meconium, a probe could not be passed into the cæcum. The cæcum was then opened and a minute quantity of solid whitish mucus found in its lumen. The lumen of the ascending colon readily admitted a probe. Inspection of the ileocæcal valve from the interior of the cæcum showed that a complete septum of mucous membrane occluded the valve, and a probe could not be passed through it. No Meckel's diverticulum or other congenital abnormality was present.

Microscopical sections through the centre of the ileocæcal valve (*Fig.* 92) showed a normal ileocæcal sphincter, with a complete diaphragm consisting of two layers of mucosa and some intervening areolar tissue. There was no evidence of fibrosis such as would suggest intra-uterine ulceration.

Case 2.—**Congenital Occlusion due to Volvulus of the Ileum.**

A female infant, 8 days old, was admitted to St. Mary's Hospital, June 12, 1920. The history given was to the effect that the child had passed what was considered to be meconium from the second day after birth, though it was very small in amount and of a light colour. On the third day vomiting began and was projectile in type. For the last three days before admission it had vomited dark-green fæculent material in considerable quantity. The family history revealed nothing of importance.

On Admission.—The infant was small, emaciated, and jaundiced, with a swollen abdomen. It passed a little mucus, faintly tinged with bile, per rectum. The abdomen showed well-marked visible peristalsis of the small-intestine type. The finger entered the rectum readily, but the rectum above the anal canal was smaller than normal. A diagnosis of congenital obstruction of the lower ileum was made, and operation undertaken as a forlorn hope.

Operation.—After subcutaneous saline infusion the abdomen was opened by an incision through the right rectus muscle. Greatly distended and hypertrophied coils of ileum full of fluid meconium were exposed. On tracing the distended bowel downwards it came to a sudden rounded end three inches above the ileocæcal valve, and appeared to be connected with the ileocæcal junction by a rounded fibrous cord. The cæcum was normally placed in the right iliac fossa and fully rotated, but, with the whole colon, was pale and contracted to a very small size, and empty. The sacculation of the cæcum was normal, and the appendix lay curled up below, and to the inner side of, the cæcum. Its base was excentrically placed, and not situated at the apex of the cæcum as in earlier intra-uterine life. Both ascending and descending mesocolon had disappeared. The great omentum extended over the front of the ascending colon, and an extension from its right margin formed a typical Jackson's pericolic membrane.

A Paul's tube was tied into the dilated blind end of the ileum, and the wound closed with the end of the ileum protruding through its lower part. Meconium drained away freely after the operation, but the child collapsed and died twenty hours later.

Post-mortem Examination. (*Figs.* 93 and 94).—The hypertrophied ileum was less conspicuous than at operation owing to the evacuation of its contents, but still formed a remarkable

contrast with the white attenuated colon, which had an external diameter of about 5 mm. Peritoneal fixation of the colon was normal, but there was a well-marked Jackson's pericolic membrane derived from the right free margin of the great omentum. There was also a pronounced

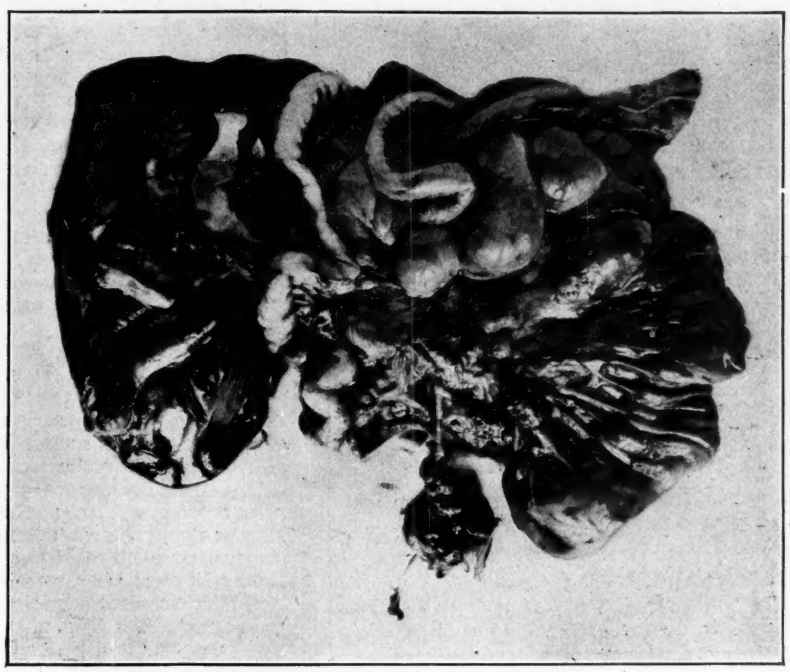

FIG. 93.—Abdominal viscera removed post mortem from *Case* 2. For explanatory diagram *see Fig.* 94.

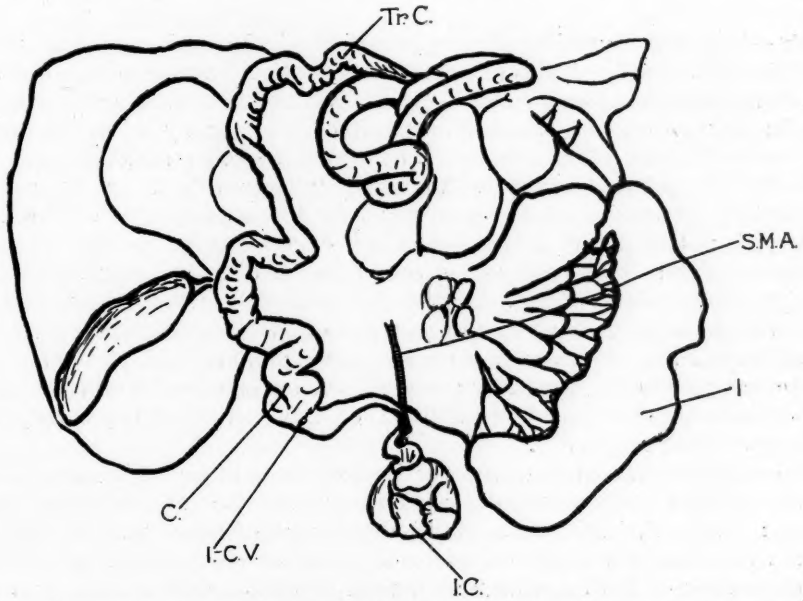

FIG. 94.—Diagram of *Fig.* 93. **I**, Ileum. **SMA**, Superior mesenteric artery. **IC**, Isolated coils of ileum. **ICV**, Ileocæcal valve. **C**, Cæcum. **Tr.C.**, Transverse colon.

ileal band (or genitomesenteric fold of Douglas Reid), which ran from the inferior aspect of the mesentery below the blind end of the ileum to the right ovary. Between the blind end of the ileum above, and the ileocæcal valve below, some tiny convoluted coils of bowel, little more than

half the diameter of the colon, blind at each end, and containing inspissated mucus tinged with bile, could be made out. These coils were made more obvious by passing a fine cannula through into the lumen and inflating them with air, which demonstrated that they formed a single tortuous portion of the intestinal tube, detached from the bowel above and below. On dissecting these coils free from the great omentum, which was adherent over the front of them and bound them together, they were found to be continuous by a slender fibrous cord with the blind end of the dilated ileum above. They were connected by a similar cord below with an attenuated and conical portion of the ileum, half an inch in length, which remained just proximal to the ileocæcal valve. Each end of this isolated segment of small intestine was in close contact with a strong fibrous cord running down from the mesentery, where it was continuous with the superior mesenteric (vitelline) artery.

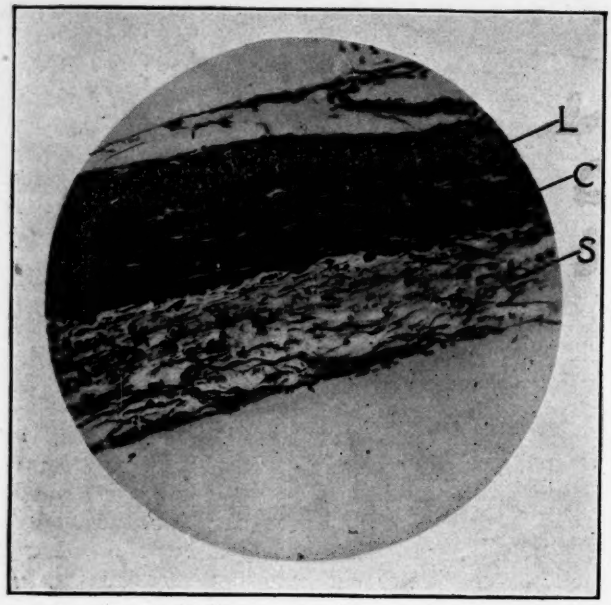

FIG. 95.—Transverse section through wall of isolated coil of ileum. L, Longitudinal muscular coat. C, Circular muscular coat. S, Submcosa.

Clockwise torsion of a segment of lower ileum round this artery as axis appeared to have taken place at an early stage of intra-uterine life, causing occlusion of the lumen of the ileum above and below the loop, and at the same time leading to fibrosis of the artery well up into the mesentery. Higher up in the mesentery the arterial arcades were normal, but opposite the isolated bowel they were deficient.

Microscopical sections of the isolated coil of ileum (*Fig.* 95) showed a normal muscular and peritoneal coat, with considerable exfoliation of the mucosa, so that the glands of Lieberkühn were only here and there recognizable.

Etiology.—The whole subject of congenital intestinal atresia was dealt with exhaustively in 1904 by H. S. Clogg,[1] who gives a survey of the literature to that date. I do not propose to cover the same ground in this communication, but rather to discuss any light that may be thrown on the obscure question of etiology by a consideration of the two cases recorded above. Clogg's summary of his conclusions on etiology may be quoted, and the reader referred to his paper. He states "that most, if not all, malformations in the duodenum are associated in some way with the development of the large glands from this region; that many single occlusions of the small intestine are referred to Meckel's diverticulum; that snaring of intestine by the umbilical ring accounts for some cases, and probably this is of more importance than has hitherto been thought; that volvulus no doubt accounts for a few cases; that there is no satisfactory evidence that intestinal ulceration has anything to do with atresia; that fœtal peritonitis has a very limited, if any, application in the cause; and that the unusual cases where multiple points of atresia or stenosis exist are very difficult of explanation and probably depend on different causes acting together".

A most comprehensive study of the relative frequency of congenital atresia in different parts of the intestinal tract was made by Forssner in 1907.[2] He classifies the cases into three groups: *Group I*, in which a simple diaphragm of mucous membrane across the lumen of the bowel causes either complete occlusion or stenosis; *Group II*, in which a breach of continuity of the bowel is found, with two blind ends united by a cord; and *Group III*, in which the breach of continuity is complete, and the two blind ends are free and unconnected. The distribution of Forssner's collected cases was as in the appended table. It is evident from these figures that my *Case* 1, with atresia of the ileocæcal valve, is a rare anomaly, and that *Case* 2, with occlusion of the ileum, falls into a much larger group.

Group I.—(Diaphragm of mucosa).

Duodenum	17	(9 atresia;	8 stenosis)
Jejuno-ileum	20	(16 ,,	4 ,,)
Ileocæcal valve	4	(2 ,,	2 ,,)
Colon	8	(7 ,,	1 ,,)
Total	49	(34 atresia;	15 stenosis)

Group II.—(Blind ends connected by band).

Duodenum	16	(11 atresia ;	5 stenosis)
Jejuno-ileum	19	(all atresia)	
Ileocæcal valve	4	(all atresia)	
Colon	1	(atresia)	
Total	40	(35 atresia ;	5 stenosis)

Group III.—(Blind ends unconnected).

Duodenum	13
Jejuno-ileum	19
Ileocæcal valve	8
Colon	5
Total	45

A survey of the recorded cases of congenital occlusion of the ileocæcal valve leads one inevitably to the conclusion that a number of these rare cases may have been published as obstruction of the bowels from undeveloped large intestine in the new-born. The attenuated, pale, and empty colon presents such a contrast with the greatly distended ileum that, without meticulous care in investigating the condition of the ileocæcal valve, it might readily be supposed that the essential error in development lay in the insufficient calibre of the colon. Such an interpretation may reasonably be placed upon several records, as for instance that of Hadra.[3] Similarly, in *The Lancet*, 1859,[4] there is recorded a case of fatal obstruction of the bowel by meconium, in which I would venture to suggest that the ileocæcal valve may have been really at fault. The presence of tough, inspissated meconium in the lower ileum of my *Case* 1 suggested this causation, until careful examination with a probe post mortem demonstrated the atresia of the valve. At the same time it cannot be denied that inspissated meconium, possibly held up by a stenosis of the valve in the first place, may cause the obstruction, since such a case has been reported by Pearce Gould.[5]

Causation of Atresia of the Ileocæcal Valve.—If we accept, as I think we may, the conclusion of Clogg that there is no satisfactory evidence that intestinal ulceration in utero plays any part in congenital atresia, we are driven to inquire whether there is any embryological evidence of an early stage of development in which the ileocæcal valve is normally occluded. Could such a phase be established, we should have a simple explanation of occlusion of the ileocæcal valve as an error in development comparable with the persistence of the proctodæal plate in imperforate anus.

Tandler[6] was the first to point out that the duodenal lumen in human embryos of thirty to sixty days normally is more or less completely obliterated. Forssner[2] confirmed Tandler's observations, and agreed with Tandler that the cause of the occlusion was the resistance exerted upon the expanding epithelium by the surrounding mesenchyme. He also considered it probable that an epithelial occlusion, of similar origin to that occurring normally in the duodenum, may exceptionally be found in all parts of the embryonic intestine. Keibel,[7] in an embryo of 11·5 mm., found that "the epithelium of the lower portion of the intestine blocked the lumen at two small places", but since similar conditions were not observed in other specimens, he concluded that "this may well be only a chance and meaningless adhesion".

It may be concluded from the above investigations that there is some definite embryological evidence that a state of occlusion, exactly similar to that normally occurring in the duodenum, may occasionally be found, in the early months of development, in the

lower ileum. The persistence of such a rare developmental anomaly would provide the most reasonable explanation of these very uncommon cases of occlusion of the ileocæcal valve. Histological examination of the ileocæcal valve in my case (*Fig.* 92) undoubtedly supports this view, since the section through the centre of the occluded valve shows a normal ileocæcal sphincter with the lumen occluded by a double layer of epithelium, and normal areolar tissue interposed. There is none of the fibrosis that would be expected if the occlusion had resulted from localized intestinal ulceration.

Causation of Occlusion in Case 2.—The fact that the torsion which led to isolation of some loops of ileum in this case occurred round the superior mesenteric artery (*Fig.* 94), is conclusive proof that the very apex of the U-shaped mid-gut loop was involved, since the superior mesenteric is identical with the vitello-intestinal artery of the embryo. A review of the recorded cases of congenital atresia of the ileum shows that it is this apex of the mid-gut loop—the site of Meckel's diverticulum, or its earlier stage, the vitello-intestinal duct—which is the commonest site of the atresia.

Clogg (loc. cit.) urges that volvulus should not be accepted as the mechanism involving the atresia in these cases without clear evidence that it has occurred. It is probable that the process of atrophy and disappearance of the vitello-intestinal duct, carried to excess, may be a cause of stenosis or atresia in this situation without any volvulus. On the other hand, it is possible that volvulus, causing separation of a loop of bowel at an early stage, may be followed by complete disappearance of the isolated loop, and that this may explain some of the recorded cases, with wide separation of two blind ends of ileum opposite a V-shaped gap in the mesentery. Such a case is illustrated in an article by Keith.[8]

Waterston[9] describes the case of a female child, operated on by Stiles, in which the small intestine ended blindly above a V-shaped gap in the mesentery. Five inches of the lower ileum were "twisted in a spiral fashion round a peritoneal cord, which proved to be a portion of the mesentery which had apparently occupied the V-shaped gap previously described". The last three inches of the ileum were normal, and mounted on a normal mesentery. Waterston suggests that the spiral twisting of the coil of ileum to the extent of three and a half turns was subsequent to its division by the peritoneal band; but a more likely interpretation of the case would seem to be that a volvulus was the primary event, and that this caused separation of a portion of bowel and mesentery. If this interpretation is correct the case is very similar to mine.

Carwardine[10] described a case of atresia of the ileum in which a Meckel's diverticulum alone had undergone volvulus. The isolated Meckel's diverticulum formed a large cyst, but the mechanism by which the occlusion of the bowel was produced was evidently similar to that obtaining in my case. A very similar effect may be produced occasionally by the snaring of a loop of ileum in the umbilical ring, as in Clogg's first case. Clogg considered that the loop involved did not recede from the umbilical cord into the abdomen, owing to some adhesion of a Meckel's diverticulum to the amnion in the third month of intra-uterine life, and that this allowed the contracting umbilical ring to trap it and isolate it from the rest of the bowel.

Since the isolated coils of ileum in my case contained only a trace of mucus, it may be concluded that the volvulus occurred before any appreciable quantity of meconium had reached the lower ileum. This fact gives an indication of the date at which the volvulus took place, since Low[11] has shown that meconium reaches the ileocolic junction in the fourth month; and there is evidence from the normal disposition of the colon in the abdomen that the torsion occurred after the rotation of the mid-gut loop at the beginning of the third month.

The atrophic condition of the isolated coils is attributable to two factors, viz.:—

1. The absence of septic organisms in the lumen.

2. The loss of blood-supply resulting from obliteration of the superior mesenteric artery.

A striking contrast with this condition of early intra-uterine volvulus of the ileum is afforded by the following case.

Case 3.—**Volvulus of the Ileum in a New-born Child.**

A male infant, 2½ days old, was admitted to St. Mary's Hospital, Dec. 3, 1920, with a history that it had passed no meconium since birth.

On Admission.—The child was very small and in feeble condition. The abdomen was very distended, and the superficial veins were engorged. There was some œdema of the lower abdominal wall. On rectal examination the anus was normal, and the examining finger passed up about two inches, when the rectum appeared to become much narrower.

Operation.—The abdomen was opened through a left rectus incision. A greatly distended, stinking, and gangrenous coil of the lower ileum presented. At the lower end of the gangrenous coil there was a sharp kink of the bowel, due to old fibrous adhesions left by some localized intra-uterine peritonitis. No meconium had passed beyond this kink, and the colon was in the same pale, contracted, and diminutive state as in the two cases recorded above. The gangrenous coil was rapidly cut away, and enterostomy performed. The child died a few hours later.

In this case the overloaded coil of ileum evidently became twisted during the process of parturition or shortly after, and enough bacteria were present in the meconium to determine gangrene and putrefaction.

In considering the mechanism of the volvulus in *Case* 2, it is not easy to explain why an *empty* coil of bowel should have undergone torsion with such serious results. The torsion occurred, however, at a period when the great omentum was actively engaged in contracting adhesions to the colon, and securing its fixation in the position peculiar to orthograde mammals. The firm adhesions of the omentum to the isolated coils of ileum in this case suggest the possible explanation that the omental adhesions perpetuated a chance position of the affected portion of the ileum, in which the blood-vessels of this segment of bowel were occluded. This occlusion would naturally be most complete at the extremities of the loop, where complete division of the bowel occurred. It is possible that complete disappearance of the whole segment of bowel would have followed, but for a secondary vascular supply derived from the adherent omentum.

Symptoms and Diagnosis.—The characteristic symptoms of congenital occlusion of the ileum are (1) Failure to pass meconium ; and (2) Vomiting, which may not begin until the child is some three days old. There may be a slight discharge of stringy tenacious mucus from the colon below the obstruction, particularly if energetic measures such as enemata have been employed. This mucus may be tinged with yellow if the child is jaundiced, and those in attendance may draw the erroneous conclusion that the obstruction is not complete. There is, however, no real resemblance between this scanty viscid mucus and the greenish-black meconium.

On physical examination the anus is found to be normal, and the examining finger passes readily through a normal anal canal into a rectum which is decidedly narrow, although a lumen can be felt. The abdomen is distended, and the distention is of the central type, without any bulging in the flanks. If the child is thin, distended coils of small intestine in visible peristalsis may be seen.

Vomiting, when it has begun, is repeated at frequent intervals, and the child brings up considerable quantities of meconium, and is unable to retain fluids in the stomach.

The condition must be differentiated from (1) *Imperforate anus* ; and (2) *Occlusion of the duodenum*.

1. In imperforate anus there is either a complete absence of the proctodæum, or, if the proctodæum is present, the examining finger is unable to pass through the anal canal owing to the obstructing proctodæal membrane. There is little possibility of confusion with the condition under discussion.

2. In congenital occlusion of the duodenum, vomiting is an earlier and more urgent symptom, and the dilatation above the obstruction is confined to the stomach and upper duodenum. In those cases in which the occlusion is above the ampulla of Vater, meconium may be voided normally, and there will be no bile in the vomited material.

Congenital occlusion of the jejunum, and the rare cases of occlusion of one or more segments of the colon, can hardly be differentiated from occlusion of the ileum before operation.

Prognosis and Treatment.—So far as I can ascertain from the literature, no case of congenital occlusion of the ileum has survived operation more than a few days, and without operation the condition is of course rapidly fatal.

The ideal of restoring the continuity of the gut, by anastomosing the dilated ileum above the obstruction with the colon below, must be set aside as futile. The tiny contracted colon, with a lumen that will only admit a probe, can never discharge its proper functions. This anastomosis has been attempted in several recorded cases, but has had to be abandoned, or has failed, in every case.

Enterostomy through a convenient part of the abdominal wall is the only primary operation that should be undertaken, and there is no apparent reason, given early diagnosis, and operation before the child is exhausted by vomiting, why a small minority of cases should not survive.

The presence of a normal anal canal and sphincter leads one to suggest that in a case that had survived the enterostomy and showed signs of a fair vitality, it might be worth while to re-open the abdomen a few weeks later, free the ileum from the abdominal wall, incise the rectum, and bring out the ileum through the dilated rectum and anal canal. This operation would afford some hope of sphincteric control. It is too severe a procedure to be attempted as a primary measure, in the presence of acute obstruction, and was only undertaken as a forlorn hope in my first case, when the laceration in the upper rectum was discovered.

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THE KONDOLÉON OPERATION FOR ELEPHANTIASIS.

By ARNOLD K. HENRY, Dublin.

Until the year 1911, the literature dealing with the treatment of elephantiasis of the limbs is either a confession of failure, or a description of barren methods which have been discarded. In that year Lanz, of Amsterdam, described an operation which he had performed on the lower limb, in a case of elephantiasis of four years' standing. This operation suggested to Kondoléon the method which he adopted a year later, and which forms the subject of this paper.

In an elephantiasis there are two chief elements: lymph stasis, and overgrowth of cutaneous and subcutaneous tissues. The stasis may be caused by disease or removal of glands to which the lymphatics converge, disease of the lymphatics themselves, or disease of the blood-vessels. The second constituent, namely overgrowth, follows the prolonged soaking of the tissues, and may gradually become elephantine. The fibrous network thickens beneath the skin, holding in its meshes enormous quantities of fat and stagnant lymph: the skin, responding to the stress coming from within, becomes coarse like that of an elephant, and the disease thus twice justifies its name.

Lanz was the first to recognize the deep fascia as a barrier to lymph absorption. Impressed with the fact that, save at their common glandular terminations, the deep and superficial lymphatics of the lower limb make few anastomoses, he recognized the deep fascia as a kind of watershed separating these two lymphatic systems. On this assumption he incised the deep fascia on the outer side of the thigh, exposed the femur behind the vastus externus, and introduced strips of fascia between the muscles, in order to effect a drainage of the subcutaneous lymph-swamp into the deep catchment area of the muscles.

Thinking the bone-marrow might afford an additional area of absorption, he also introduced pedicled strips of fascia into the medullary cavity through holes drilled in the bone. He then closed the skin without drainage. Immediate diminution in the size of the limb resulted, and three years after the operation this improvement was maintained.

Kondoléon, as a result of operation and experiment, concluded that small slits in the deep fascia were inadequate for good drainage. He also failed in a case where, following Lanz, he had introduced fascial strips between the muscles.

This work, however, impressed him with the fact that the bulk of the stagnant lymph lay in the loose connective tissue immediately adjoining the deep fascia, and in two of his cases Kondoléon found this lymph-logged stratum differentiated into a distinct and separable layer. He then attempted to effect adequate drainage of the subcutaneous tissue into the muscles through wide openings in the deep fascia, and with this method he succeeded in eight cases.

Moschowitz, Sistrunk, and others have repeated his successes in America: seventeen cases have been recorded in all.

It seems to me that the presence of connective-tissue overgrowth, dividing as it does the subcutaneous area into a loculated mass, does much to explain the failure of the earlier operations for elephantiasis. Handley, for instance, has expressed the view that "lymphangioplasty has failed to establish its position in the treatment of this disease". This conclusion is not unnatural, for, if the subcutaneous area is become in any degree alveolar, attempts at permanent drainage by means of silk strands must be futile. One might as well try to drain all the honey from a bee-hive by running a couple of threads through the combs.

This loculation of the subcutaneous lymph into little pools explains why, in old-standing cases, cures are not complete ; for only the pools in the immediate neighbourhood of the openings made in the deep fascia will be tapped, leaving a vast lacunar swamp undrained.

This, I believe, is the explanation of Kondoléon's success with wide openings in the deep fascia, and I think it follows that, in an old-standing case, openings should be made in each area where drainage is desired ; for, in such a case, drainage will be purely local, and resection, for example, of the fascia lata, while it will drain the adjacent tissues of the thigh, will not relieve the lymph stagnation in the leg.

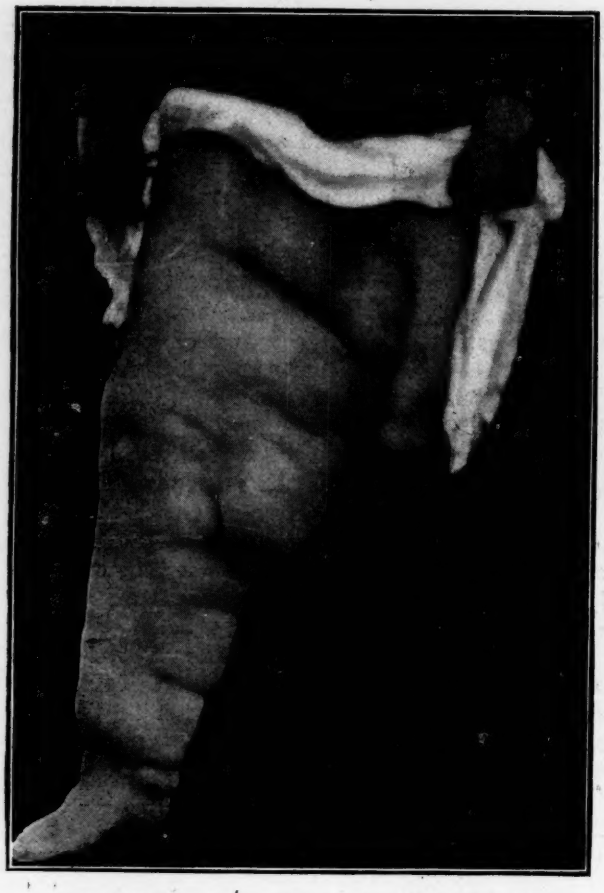

FIG. 96.—Showing the condition one year previous to operation. During this period the proximal fold in the right thigh had become pedunculated, and at time of operation hung down almost to the level of the knee.

Handley's successes with lymph-angioplasty in the treatment of œdema of the upper limb following cancer of the breast are explicable, perhaps, by an absence of subcutaneous loculation ; for, by comparison with many cases of elephantiasis, the œdema in cancer is of short duration ; the subcutaneous pools communicate, and the threads drain them all.[1]

In April, 1917, I had an opportunity of putting Kondoléon's operation to a severe test. The patient, a French woman, age 34, with three healthy children, gave a negative family history, and a vague account of some kind of inflammatory trouble in her right leg at the age of seven. She had always lived in France. For twenty-seven years the limb had gradually been increasing in size. *Fig.* 96, which is taken from a photograph kindly given me by Mr. R. Atkinson Stoney, shows better than description the condition as it was in 1916, one year previous to operation. When I saw her for the first time, a year later, the proximal fold which appears on the inner side of the thigh had become a pouch, and hung down like a huge scrotum almost to the level of the knee, greatly impeding her gait. This, indeed, was her chief complaint, and she came to request its removal. She also complained of attacks of shivering, followed by fever, occurring about once in four months. During these attacks, which lasted for three or four days, the limb became red, painful, and more swollen than usual. The skin of the affected limb was harsh, dry, and greyish-brown, except in the creases of the skin folds, where it was pink and moist. The foot was quite unaffected. For about a week before operation the patient was kept in bed. At the end of that time there was practically no diminution in the size of the limb.

At operation, I first amputated by an elliptical incision the scrotal-like swelling which hung down almost to the knee, and then excised a hand's breadth of the deep fascia subtending its base, together with the greatly thickened subcutaneous tissue which lay at the periphery of the wound. The skin was closed over the bared muscles with mattress sutures

of silkworm gut, threaded on either side through rubber tubing, and also with interrupted skin sutures of the same material. An incision including a wide strip of skin was then made along the whole length of the outer aspect of the thigh, and a hand's-breadth of deep fascia of the length of the incision was resected, together with as much subcutaneous tissue as was accessible. This wound was completely closed like the first. The deep fascia was about a quarter of an inch thick, and was 'felted' on its superficial aspect. The wounds healed without incident, except that, from the upper end of the inner incision, clean lymph oozed freely at first. This oozing had ceased by the fourteenth day.

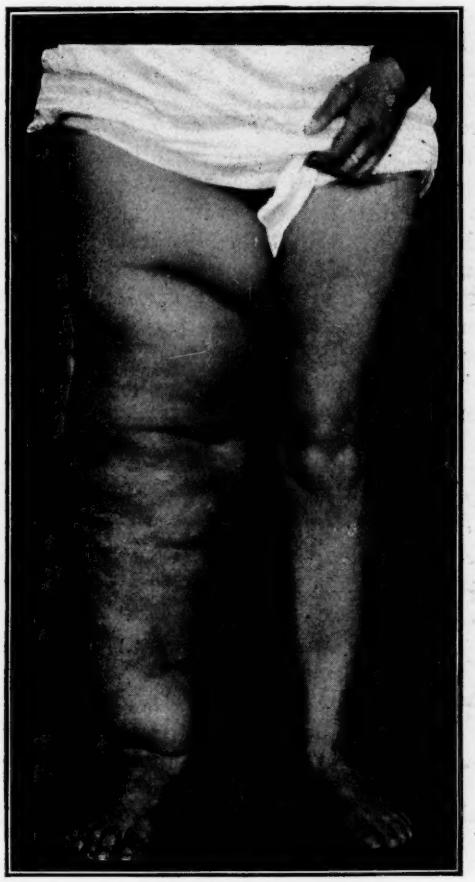

FIG. 97.—Showing the condition 11 months after the first operation and 4 months after the third operation.

FIG. 98.—Same as *Fig.* 97. Posterior view.

A month after the first intervention I again operated, using the same technique. On this occasion the huge oblong cushion along the lower two-thirds of the inner side of the thigh was removed.

This time, in closing the wound, sutures were passed so as to pick up the exposed muscles and bring them into contact with the subcutaneous tissue. The wound on this occasion took slightly longer to heal, continuing to discharge lymph at one point for three weeks.

When I saw the patient again, five months later, in November, 1918, she was so pleased with the results of the first two operations that she asked me to try to improve the remaining condition.

On Dec. 9, 1918, we decided that in view of the extensive resection contemplated,

time would be saved if, while one of us dealt with the enormous cushion of elephantoid tissue that persisted over the hamstrings from the popliteal space to the gluteal fold, the other excised the great wad extending over the calf to the ankle. This was done with the patient in the prone position, Dr. D. Milne Henry operating on the leg, whilst I worked on the thigh.

Figs. 97, 98, 99 show the condition of the patient four months after this last operation, and eleven months after the first. The long duration of the condition in this case makes it a severe test of Kondoléon's method.

I would repeat that the drainage effected is a *local* drainage, and although, as the illustrations show, the limb is still much larger than its fellow, it is considerably smaller than it was, and the condition has not recurred in the areas of operation, where previously it was progressing fast.

FIG. 99.—Lateral view, taken at same time as *Figs.* 97 and 98.

While appreciating to the full the practical merit of Kondoléon's procedure, it is difficult to agree with the theory on which it is based. Kondoléon assumes that, by resecting deep fascia, he allows the subcutaneous lymph to drain into the deep lymphatics. I submit that if the actual result of this resection were to throw the task of drainage upon the deep lymphatics, Kondoléon's operation would often fail in the very cases where it has succeeded best. Kondoléon claims that his most satisfactory results have been obtained in cases of elephantiasis due to filarial infection. Now in this disease the filariæ are not confined to a single group of glands, such as those which drain the superficial lymphatics of the lower limb, but are distributed throughout the lymphatic system of the pelvis. Of these pelvic glands, those grouped about the termination of the external iliac artery receive the efferent lymphatic vessels, not only of the superficial inguinal glands, but of the deep inguinal glands also. It is most unlikely that the widespread invasion which is blocking the superficial inguinal glands will spare the adjacent glands of the external iliac group, which are the ultimate goal not only of the main lymphatic inflow from the thigh, but of *all* the lymph carried by the lymphatics of the leg, both deep and superficial.*

The success of the operation makes it difficult to believe that the drainage actually established in these cases can be by way of the deep lymphatics, since the glands to which these deep vessels converge are just as likely to be impermeable as those which are blocking the outflow from the superficial lymphatics.

Again, in the upper limb, with the exception of those superficial vessels which pass to the infraclavicular glands, the superficial and deep lymphatics converge upon the same

* Kondoléon himself describes a successful result obtained by his operation in a case of elephantiasis due to *complete* removal of the inguinal lymph-glands. Here, both superficial and deep lymphatics would, presumably, be blocked at their extremities, and it would thus be useless to drain the territory of one set into the other. But it is, perhaps, unfair to take his ' complete ' in the strictly anatomical sense of including both the superficial and the deep inguinal glands.

group of axillary glands—the lateral or brachial group, which lies in relation to the axillary vessels. A removal of fascia from the upper limb would, on Kondoléon's theory, seek to divert the lymph to the very group of glands whose impermeability was blamed for the disease.

It might, of course, be objected that superficial and deep vessels of the upper limb may be received respectively by separate members of the group to which they pass, and that a path for the deep lymph might remain clear through certain fortunate glands of the group which were still permeable. It is difficult to accept this explanation, in view of Sistrunk's success with Kondoléon's operation in a case where elephantiasis of the upper limb followed a clearance of glands from the axilla. It is extremely improbable that, in this case, a deep lymphatic path persisted through any glands of the common brachial group, which receives both sets of lymphatic vessels; and it would be deliberate imprudence to perform any operation which depended for success upon so slight a possibility.

By what channel, then, is the lymph absorbed which passes through the openings cut in the deep fascia?

Starling, in the last edition of his *Principles of Human Physiology*, states that *rapid* absorption of substances injected into the tissues takes place by way of the blood-vessels. If strychnine is injected into the distal part of a limb, symptoms of poisoning occur almost as rapidly after section of all the tissues of the limb except the main artery and vein, as if a normal limb is injected. Again, if methylene blue is injected into the pleural cavity or subcutaneous tissues, the dye appears in the veins long before any trace of colour can be perceived in the lymph flowing from the thoracic duct. I think it is clear, therefore, that in cases of elephantiasis due to the blocking of lymph-glands, and treated by Kondoléon's method, the superfluous lymph is absorbed by the blood-vessels of the muscles and not by the deep lymphatics. It should be noted, however, that one case of elephantiasis operated on by Kondoléon was attributed to venous obstruction; and one may assume with MacCallum (*Text Book of Pathology*, 2nd edition, p. 44) that the lymphatic and venous outflow from a part are, in a sense, alternative: if the veins of a limb are tied, the flow of lymph from the lymphatic trunk is greatly increased.

It is a little difficult, however, to understand why it is that the blood-vessels of the muscles should be competent to carry off the superfluous lymph, while those of the skin and subcutaneous tissue, which are so numerous in elephantiasis, are unable to remove it. Without venturing into the very controversial question of lymph formation and œdema, it seems to me that there may possibly be a simple physical factor which makes absorption easier for the blood-vessels in the muscle strata than for those under the skin.

The subcutaneous tissue, as I have said, tends in elephantiasis to fibrous intersections, which divide the lymph into pools; whereas the muscular strata in the limbs afford intervals in which a fluid might, as it were, be moulded into delicate laminæ and take the cast of the capillary interstices of the muscles. Presumably blood-vessels would more easily deplete these intermuscular pellicles than they would pools in the subcutaneous tissues.

To test this hypothesis of physical facilitation, I injected a coloured fluid into the limb muscles of a dead rabbit. Contrary to my expectation, I found that when the limb was skinned and viewed by transmitted light, the fluid, when injected into a muscle belly, formed a globular drop, and did not spread between the fibres of the dead muscle.

Very different, however, was the effect of making an extramuscular injection under the deep fascia, or under the muscle-sheath. A wide and instantaneous spread was observed like that of a drop between a glass slide and its cover-slip. A similar spread, no less swift, but columnar rather than laminar, was seen on injecting the intermuscular spaces, especially those adjacent to the long bones of the limb. It is very possible that this physical facilitation of absorption in the muscle strata contributes to the success of the Kondoléon operation.

Apart from the protoplasmic phenomena, there is in all probability a dynamic part played by the muscles themselves in pumping lymph from the stagnant subcutaneous

swamp into the absorbent strata of the muscles. It may be argued that the opening cut in the fascia is soon blocked by dense fibrous tissue; but a consideration of three suggestive facts inclines me to doubt that this necessarily occurs. In the first place, every one is familiar with those tedious wounds which expose the extensor muscles in the leg, and are kept patent by the shearing stress exerted by their contractions. Secondly, muscle herniæ are very common after wounds of the deep fascia. Observation of these herniæ leads me to conclude that they are especially prone to occur where the wound in the skin is of smaller extent than that in the fascia, or where the superficial tissues have healed *rapidly* over the fascial defect, and this is precisely the condition secured in the Kondoléon operation by suturing the skin. Thirdly, in using local anæsthesia in operations for inguinal hernia, I have often observed that the solution which I have injected into subcutaneous tissue, and into subcutaneous tissue only, has penetrated all the coverings of the hernia, and has anæsthetized the neck of the sac without any supplementary injection being made. In cases of muscle herniæ the fascial defect is so thinly patched that during contraction the muscle belly bulges freely, like an abdominal hernia into its sac, and there is certainly no reason to suppose that the thin coat of a hernia is less permeable to fluids when it contains muscle than when it contains gut.

I would suggest, then, that Kondoléon's operation actually produces a series of wide muscle herniæ, and that the alternate bulging and withdrawal of the muscles at the fascial openings probably serves to aspirate fluid from the subcutaneous tissue into the muscular strata.

During contraction, a muscle like the biceps must tend to cause a negative pressure in those parts of the intermuscular spaces from which it recedes, while at the same time raising the pressure where it expands. If, then, an opening is made in the fascia covering the muscle belly, lymph will be aspirated through this opening when the muscle elongates. During contraction the muscle bulges into the opening, and closes it against the egress of the aspirated lymph. This lymph is then distributed under positive pressure in thin pellicles or slender columns to the extremities of the muscle, where a negative pressure has developed during the contraction of its belly.

In actual practice, of course, the relative positions of the contracting belly and of the fascial opening will often make this muscle-pump a leaky and defective instrument. On the other hand, it is impossible to deny the importance, in treating elephantiasis, of any factor which secures, if only for a moment at a time, the repeated influx of lymph into a region with a special faculty for absorption, and where experiment shows that even after death fluids will easily spread.

I hope, in this connection, to deal in a later paper with experiments upon muscle herniæ, and the nature of repair and absorption at fascial openings.

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INJURIES OF THE DIAPHRAGM: WITH SPECIAL REFERENCE TO ABDOMINOTHORACIC WOUNDS.*

By C. W. GORDON BRYAN, London.

Injuries of the diaphragm are of consequence partly on account of the important physiological functions in which the muscle is engaged, partly because of its close anatomical relationship to important viscera of the abdomen and thorax. The effects of such injuries have been met with much more commonly in recent years than in previous times, and the reasons for this are clear: street accidents, so frequent in these days of motor transport, are responsible for most of the cases seen in civil life, and the great War, with the numerous smaller wars that have succeeded it, have brought a very large number of cases under the care of military surgeons. As a weapon of revenge the popularity of the dagger has waned, but the revolver has a prominent place in methods of reprisal, and the diaphragm often suffers. In the cases usually met with in civil surgery, the muscle is ruptured as a result of crushing violence, whereas injuries seen in military surgery are commonly produced by an open wound.

Each of these types of injury produces consequences of surgical importance at two stages—an early stage in which serious symptoms follow immediately after the injury, and a late stage where the patient suffers from certain special complications months or years afterwards.

I propose, then, to consider the subject of this lecture in two parts, dealing first with the early effects of injuries of the diaphragm, and afterwards with their late effects.

EARLY EFFECTS OF INJURIES OF THE DIAPHRAGM.

Injuries without an External Wound.—When the diaphragm is injured by severe external violence in the nature of a crush, it may be ruptured by a stretching and bursting mechanism, or it may be torn by the sharp end of a fractured rib; such cases are of two types, according to whether the vault or one of the crura of the muscle is implicated.

Rupture of the Vault of the Diaphragm.—Rupture of the vault is a commoner lesion than rupture of a crus, and is usually due to a person being run over. It occurs most frequently in children and adolescents, because their thoracic skeleton is elastic, and can be compressed to a considerable degree without fracture. In adults, on the other hand, the force of such crushes is met by the more rigid bones and cartilages and the less mobile viscera, so that the usual results are fracture of ribs, rupture of abdominal viscera, or an association of both these elements. Most of the cases of this injury in adults have been complicated by fractures of the lower ribs of both sides.

The mechanism of simple rupture of the diaphragm is of interest; and in this connection I have had convincing personal proof of the amount of compression and displacement that the thoracic wall and upper abdominal viscera can withstand without harm, for at the age of eighteen it was my fortune to be run over by a motor-bus, weighing about two tons and containing six people, the back wheel passing over the right hypochondrium and lower chest, across the sternum, and the left shoulder. After the accident no lesion was discoverable, until the right side of the chest-wall fell in three days

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* The Hunterian Lecture delivered before the Royal College of Surgeons of England on February 4, 1921.

later, as a result of the separation of the attachments of the right costal cartilages. Two years ago I saw a precisely similar condition in a girl of three years, run over by a car which passed obliquely across the left hypochondrium and right chest, and caused no apparent injury beyond costochondral dislocations.

E. T., a girl, age 3 years, was admitted to St. Mary's Hospital, Sept. 13, 1919, immediately after being run over. Temperature 98°, pulse 132, respiration 32. Right thoracic wall displaced forwards; 'clicking' sound audible at each respiration; no other abnormality detected on percussion and auscultation; abdomen rigid on palpation, but moving well with respiration; lips cyanosed.

Treated by strapping chest, after applying a pad to right of sternum. On the next day there were no abdominal signs or displacement of the heart, and the child went home in good condition on the sixth day.

Such escapes are to be considered fortunate, for it is by similar violence that rupture of the diaphragm is caused.

Pathology.—A tear of the right side is very uncommon owing to its relation to the liver, which, being comparatively immobile, has to bear the brunt of a compression injury of this region; a tear of the diaphragm associated with rupture of the liver is overshadowed by the more serious injury, and is only of clinical importance if it causes a right-sided hæmothorax. I have seen a case of severe reactionary hæmorrhage from the liver into the pleural cavity through an opening in this part of the muscle. On the other hand, the mobility and elasticity of the viscera on the left side enable them to act as a sort of air cushion and transmit the force to the stretched diaphragm, and it is ruptured; the tear usually occurs in the posterior part of the muscle, and sometimes extends into its œsophageal opening.

Symptoms.—The symptoms at first are those of shock, dyspnœa, and disordered action of the heart. The breathing presents certain typical characters; its rate is little altered, but it is almost entirely thoracic in type, with a catch at the end of inspiration (sometimes definite spasm or hiccough); painful and repeated cough may occur, and the lips are blue. The pulse is rapid and irregular.

After about twenty-four hours the patient may recover from shock, and diaphragmatic breathing is restored by the tear becoming plugged with omentum. The left lung is usually in a state of partial collapse, but in several instances the patients have appeared remarkably free from symptoms after the first two days.

The early development of a hernia of the stomach into the left pleural cavity, usually accompanied by omentum and transverse colon, gives rise to vomiting and other signs of obstruction, but with absence of distention. Dyspnœa and tachycardia recur, from displacement and compression of the lung and heart. Severe pain is present in two situations: in the abdomen, accompanied as a rule by moderate rigidity of the left hypochondrium, and in the neck or shoulder—a symptom of great significance, to which Mr. Zachary Cope[1] has recently directed attention in disease of the diaphragmatic peritoneum. The chest signs resemble those of hydropneumothorax.

The hernia may reduce itself and recur later; it may become chronic; or it may lead to early death from shock and obstruction.

Diagnosis.—The difficulties of diagnosis of these cases are well known, and *x*-ray examination, even if the patient is fit for it, may be fallacious, for it is often quite difficult to persuade an opaque meal to enter the supradiaphragmatic portion of the stomach.

Treatment.—In war surgery it was pointed out first by Lockwood[2] that the cardiac and respiratory embarrassment of wounds of the diaphragm was very similar to that of open pneumothorax, and that the condition of patients improved as soon as the communication between thorax and abdomen was closed. It seems to be essential that the central tendon of the diaphragm be anchored if the heart is to escape embarrassment, and a communication between pleura and peritoneum heavily handicaps respiration. It is this consideration that makes early operation of importance in cases of simple rupture of the muscle; and the poor condition of the patient is no contra-indication, for the rapidity

of the pulse, being partially due to mechanical causes, is no criterion of the degree of shock.

The left side of the diaphragm may be approached from above or from below. Judging chiefly from an experience of war injuries, I prefer the thoracic route, as it gives an easier access for the reduction of viscera, for dealing with associated injury of the spleen or cardiac end of the stomach, and for closing the defect in the diaphragm; but in some cases signs of rupture of intestine make an abdominal incision preferable.

A case admitted to St. Mary's Hospital illustrates the early effects of simple rupture of the diaphragm.

D. G., a girl, age 5 years, was run over by a taxi-cab on Jan. 8, 1917. Vomited immediately, and soon after admission twice vomited a small amount of blood and mucus.

Severe shock, lying on left side with knees drawn up; abdomen, extensively bruised, immobile. No signs of fractured pelvis, internal hæmorrhage, or ruptured viscus.

After forty-eight hours condition good, taking ordinary food; six days later, half an hour after dinner, severe pain in abdomen and back of neck, and any food was vomited at once. On seventh day signs of fluid and air in left chest, heart apex-beat 1 in. to left of sternum; pulse feeble and rapid, temperature 96°. Vomiting after all food, severe pain in neck. Symptoms abated next day, but recurred on tenth day.

Diaphragmatic hernia diagnosed by surgeon, but *x* rays showed bismuth passing normally below diaphragm, and radiographer considered the case hydropneumothorax. Extreme collapse precluded exploratory operation, and death occurred on eleventh day.

Autopsy.—Tear of left part of tendon of diaphragm; whole stomach, omentum, and part of transverse colon in left pleural sac; tear of peritoneal coat of stomach, which was greatly distended and contained bile; retroperitoneal hæmorrhage round right suprarenal body and duodenojejunal flexure. Left lung completely collapsed.

The alternating periods of severe illness and apparently normal health made the case one of great difficulty; the hernia evidently had reduced itself after its first appearance, only to recur with fatal result.

Rupture of the Crus of the Diaphragm.—Rupture of the crus must be an uncommon injury. I have seen one example, in association with fracture of the spine. The diaphragm injury was of clinical importance, as it gave rise to great respiratory distress, and intraperitoneal hæmorrhage which simulated rupture of a viscus. In such a case one cannot delay for the presence or absence of peritonitis to settle the diagnosis. Having diagnosed injury in the neighbourhood of the crura of the diaphragm, with possible rupture of the duodenum, exploration was undertaken, under gas-oxygen. The abdominal wall was infiltrated with novocain (0·25 per cent), and a left paramedian incision, carried outwards through the left rectus opposite the umbilicus, gave good access with the minimum of retraction—so frequently the cause of operative shock. The diaphragm, the cardia, and the duodenal region were examined thoroughly, and the bleeding was controlled with a fair degree of ease.

C. R., male, age 40, fell more than thirty feet, landing on pavement in sitting attitude, on April 1, 1920. Admitted at once to St. Mary's Hospital suffering from severe shock, compression fracture of the 11th and 12th dorsal vertebræ, and fracture of pelvis; signs of intrathecal bleeding developed later, pain and weakness of legs, with anæsthesia to level of left knee.

Five hours later, vomiting of altered blood, severe abdominal pain. Temperature 98°; pulse 104; respiration 22, shallow, of thoracic type, with catch at inspiration, alæ nasi working; small area of rigidity, right upper rectus.

Operation.—Rupture of internal part of left crus of diaphragm from which, and from œsophageal branches of coronary vein, blood escaped through a tear in overlying peritoneum. The bleeding was arrested, neighbouring structures examined, dilated stomach washed out, and abdomen closed.

From second to fifth day, hiccough and slight vomiting. Complete recovery from all injuries, leaving hospital Aug. 14, 1920.

Simple Laceration of the Diaphragm by a Fractured Rib.—Penetration of the diaphragm by a rib which has sustained a simple fracture usually results from direct violence to the ninth or tenth rib, and the bone may also lacerate the spleen or liver.

It is not, I think, commonly realized that this is the mode of injury in some cases classed as rupture of the spleen, and that the severity of the symptoms is partly due to

hæmorrhage, and partly also to the handicap that injury of the diaphragm places on heart and respiration. The chances of recovery are improved by closing the opening in the muscle.

In dealing with a bleeding spleen through an abdominal-wall incision, considerable manipulation may be necessary, and the difficulty of exposure makes anything short of splenectomy almost impossible. Since it is known from experience of recent years that the old fear of opening the pleura was an unnecessary one, the advantages of approaching certain injuries of the spleen through the chest-wall are definite—especially injuries due to rib fracture.

In the absence of fracture, the tenth rib may be resected and the pleura pushed aside ; if a fracture is present, the broken rib is removed, the openings in pleura and diaphragm are enlarged, and their edges sutured together to close the pleural sac. The exposure of the spleen thus obtained allows of the damaged portion being sutured or resected, procedures of far less severity than splenectomy ; if removal of the organ is necessary, the manipulation of the pedicle, so productive of shock, can be carried out more gently than through an abdominal incision.

Dealing with injured abdominal viscera by transthoracic laparotomy is not new, for in 1912 Sauerbruch[3] described three cases on whom he operated under differential pressure : in one, through an incision of the seventh interspace, he removed the spleen for splenic-vein hæmorrhage, and sutured a laceration of the lung ; in another, he sutured a bullet wound of the right lung, and dealt with a wound of the liver, through an incision in the sixth intercostal space ; and in the third, he opened the seventh left interspace and repaired abdominal and thoracic injuries. He advised that the diaphragm be incised across, or obliquely to the direction of its fibres, to avoid phrenic-nerve injury. Bulkeley[4] dealt with a stab wound of the spleen through the diaphragm.

Conclusions.—It appears then that simple rupture of the diaphragm causes symptoms which may be easily overlooked or attributed to shock and hæmorrhage. Such rupture may be associated with bleeding from spleen or liver, and in operating for these conditions the diaphragm should be examined and sutured if torn, in order to relieve the immediate embarrassment of heart and lungs and to prevent diaphragmatic hernia.

Fracture of ribs causes laceration of the spleen, and the latter should be dealt with by partial resection or suture when possible, performed through a thoracic exposure.

Penetrating Wounds of the Diaphragm; Abdominothoracic Wounds. — While I realize that the partial cessation of war makes these injuries to some extent a matter of historical interest, at least it is recent history. In spite of all hopes, wars have not finally ceased, and it is reasonable to expect that the opportunity may be forced upon some of us to return reluctantly to military surgery ; moreover, in civil war, and even in peace, penetrating wounds of the diaphragm do occur from time to time.

Such wounds had a very high mortality in the great War ; large numbers came to casualty clearing stations, smaller numbers were seen at the base hospitals, and their severity made one realize how many deaths on the battlefield and in field ambulances must have resulted from wounds implicating the diaphragm.

As is well known, it was the experience of the South African War that caused surgeons, in the earlier months of the war in France, to abstain from operation in wounds of the abdomen, and active surgery was reserved for such later complications as abscess. The results of conservative treatment were soon apparent—the mortality was enormous—and in 1915 it was established that the correct treatment of wounds of the abdomen, with certain exceptions, was early operation ; the exceptions were some types of wounds of the upper abdomen from which the death-rate did not seem so high.

Severe wounds involving the thorax as well as the abdomen were judged to be outside the range of active surgery ; in fact, as late as 1918, the translation of Abadie's book[5] stated that " thoraco-abdominal association is either benign, justifying simple abstention, or so serious as to render illusory the benefit of intervention in almost all cases ". At this earlier period the treatment of these wounds was little more advanced than in the time of Waterloo. Guthrie,[6] in his book which deals with the war surgery of that period

and of the Crimea, gives details of a series of cases of wounds of the diaphragm. He states that wounds of this muscle were known to the older surgeons from the time of Paré; they knew that such wounds were not immediately, though as a rule eventually, mortal; that abdominal viscera sometimes passed through wounds of the diaphragm into the thorax, and that wounds of this muscle never closed "except under rare and particular circumstances", but were always a source of danger to life unless the liver or spleen filled the opening. He called attention to the peculiarity of the breathing—dyspnœa with a "peculiar sort of jerk or spasm"—and to the important symptom of pain on the top of the shoulder, with loss of power of the arm. In treatment he laid chief stress on the necessity for free external opening for the discharge of matter, on free bleedings and purgings of the patient, and the use of opium.

In France our cases were treated at first either conservatively, or mere provision for drainage was made. Then the early operative treatment of wounds of the chest was developed, thanks to the enterprise, in the British Army, of Mr. Gask, and its striking success soon led to its extension to the more severe abdominothoracic wounds; we closed instead of enlarged the wounds, blood transfusion became a routine procedure, and extensive operations of excision and repair were carried out. These wounds were very common, and this is easily understood when we bear in mind the position of the diaphragm above the centre of the body, and the large target that its sloping surfaces offer to missiles from whichever direction they approach. The conditions of warfare made them particularly serious, even in comparison with similar wounds met with in civil life.

It was soon apparent that operations on the trunk, with after-treatment usually carried out in a tent, were much more disappointing in winter than summer. And at all times of the year soldiers on active service are not in good condition for surgery of this severe nature; excessive cigarette smoking, often right up to the time of operation, made the anæsthetic difficult and increased the risk of post-operative bronchitis in chest cases; while constipation added to the dangers of abdominal wounds and the difficulties of their surgery; the co-existence of both factors made abdominothoracic cases particularly dangerous.

The wounds were usually due to bullets or fragments of shell or bomb; in fact, during my service as a surgeon for more than four years in France and Belgium, I never met with a bayonet wound of the diaphragm. Of a series of 50 cases, 16 were due to bullets, 34 to shell or bomb. These include all those of whom I have notes taken between August, 1917, and the conclusion of hostilities; they include all cases upon which I operated during that period. They are unfortunately only a part of those I made, for I kept records also of all wounds of the trunk admitted to the clearing station to which I belonged, but not submitted to operation owing to the pressure of more hopeful surgery. These records were lost during the rapid travelling that was forced upon us in March, 1918, and they included many cases due to bullets or small fragments of shell for whom operation appeared less urgent, as well as those of bad prognosis. Except at times when the numbers of wounded necessitated the exclusion of such cases, I thought it right to operate on the most desperate ones, not only in the hope of occasional successes, but also because a policy of despair is bad for morale. Of the 50 cases, 26 were evacuated to the base, and 24 died in the clearing stations.

Prognosis.—The prognosis in shell wounds depended partly on the size of the fragment: a man rarely reached England with a large fragment retained in thorax or abdomen; such patients either died, or had the missiles extracted in France.

The most complicated case upon which I operated was wounded by a very large piece of bomb which entered the epigastrium, and, among other things, completely bisected the stomach.

Case 18.—Gunner T. H., wounded 7.30 a.m., Dec. 15, 1917. Admitted 2½ hours later with large wound of left epigastrium; collapse, dyspnœa, pulse 140. After two hours' 'resuscitation', pulse 108.

Operation.—Wound excised, stomach found divided into two almost equal parts, jejunum

divided, large hole in transverse mesocolon, lacerations of liver, spleen, and splenic flexure; very large projectile embedded in left dome of diaphragm; fractured ribs. Foreign body removed, and stomach, jejunum, spleen, diaphragm, and transverse mesocolon sutured; wound closed; splenic flexure colostomy through separate incision. Death same day.

This case illustrates the apparent improvement that may follow treatment by rest and warmth, and the difficulty of deciding before exploration whether active surgery can help; it was remarkable that the man reached the clearing station and lived through the operation.

The most serious elements of a wound traversing the diaphragm may be: (1) The actual opening in the muscle; (2) The injury of thoracic organs; (3) The abdominal lesions; (4) Severe injuries of abdominal and thoracic viscera in the same patient.

The danger of the actual opening is twofold: it considerably handicaps the respiration and circulation of a man suffering from shock and hæmorrhage, and it allows the escape of abdominal contents into the thorax at once or at a later date; and it enables infection to spread from below the diaphragm to the pleura, and vice versa.

The thoracic injuries interfere with respiration from collapse of the lung, hæmothorax, and pneumothorax; and they may endanger life by loss of blood, sepsis, and injury of the heart. The dangers of the abdominal lesions are hæmorrhage, sepsis, intestinal obstruction, and interference with processes of metabolism, such as may result from a wound of the liver.

THE DIAGNOSIS of injury of the diaphragm can usually be settled in through-and-through wounds of the body by estimation of the line that the missile has taken; if the projectile is retained, its localization by *x* rays and the character of the breathing—thoracic in type, with a catch at the end of inspiration—are the indications of most value.

The patients usually arrived at the clearing station in a condition of shock, cold and exhausted; at this stage, estimation of the blood-pressure gave a more useful indication of their state than the pulse-rate; the slow pulse of men wounded in the liver is apt to be deceptive.

TREATMENT—GENERAL CONSIDERATIONS.—In most cases resuscitation by rest and warmth was necessary, but prolonged delay is dangerous; the delay caused by sending special cases to special wards on arrival seemed to me a thing to be avoided, but special wards for after-treatment were of great value. The primary objects of early operation in chest wounds are the prevention of sepsis and the closure of an open wound of the pleura, and the same considerations apply when the abdomen is also involved; but here the further complication of serious internal or external hæmorrhage is more often present. Every hour of waiting diminishes the chances of success.

Clean bullet wounds, and small through-and-through shell wounds, often did well without operation, hæmothorax being dealt with by aspiration repeated at short intervals, keeping the pleura as dry as possible. In some of the lighter cases such simple operations as excision and suture of the wounds of the thoracic wall and the diaphragm were performed, especially for through-and-through wounds fracturing a rib; but experience of sepsis of lung and pleura, extraperitoneal cellulitis, and abscess of the liver convinced me that thorough cleansing, or excision, and repair of the whole track of the missile, especially if it was retained, was the safer policy. Conservative surgery should be reserved for special times, such as cold weather and shortage of stoves. Radical treatment is specially necessary where a wound is due to a projectile of any size, for lacerated muscle and fractured bone will surely become infected if not excised; a large projectile usually carries in cloth, and if retained in a viscus always causes infection; a large wound of the thorax remains open, or if closed at first will re-open, producing the conditions known as 'sucking' and 'leaking' wounds; and a large wound of the diaphragm by remaining open impedes the action of heart and lungs, and is likely to lead to diaphragmatic hernia.

The severity of the patient's general condition is no bar to active surgery, for, to a man who appears very ill soon after the receipt of a wound of the diaphragm, operation usually holds out the only hope of recovery, and it is often impossible to estimate to what extent symptoms are due to hæmorrhage, to mechanical interference with thoracic

viscera, and to hernia of abdominal contents, all of which can be corrected by early operation.

Operative Methods.—Two general methods of operation for abdominothoracic wounds have been employed by different surgeons :—

A. Operation through an abdominal incision, repairing the diaphragm from below, and dealing with the visceral lesions ; a separate incision of the thoracic wall being made, if necessary, for repairing the intrathoracic injuries.

B. An incision through the lower part of the chest wall, carried forwards and downwards into the abdominal wall in certain circumstances ; the wound of the diaphragm is excised and repaired, and the lesions of thoracic and abdominal viscera are dealt with through the one incision.

It has been found possible to deal with most of the abdominothoracic wounds by the latter type of operation, and I will give a general description of its stages.

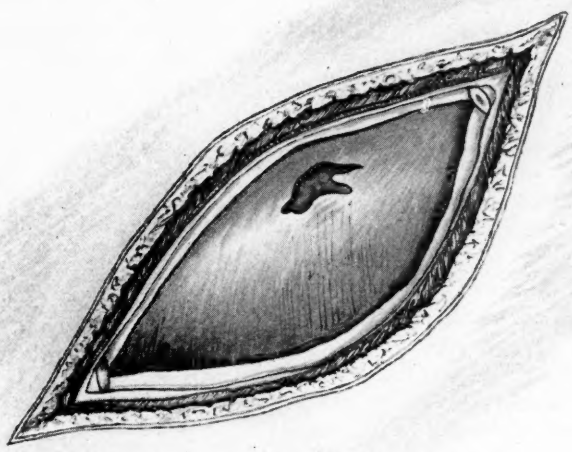

Fig. 100.—Excision of wound of chest wall and fractured rib, exposing wound of diaphragm.

1. If there is a wound of the lower part of the thoracic wall, it is excised with the injured muscle, bone, and pleura in one piece, and enlarged sufficiently to give access to the path of the missile (*Fig.* 100).

2. Any lesion of the lung is then dealt with, pieces of metal, cloth, and bone being removed, and the contaminated portion of lung is best excised and sutured.

3. The pleura is then cleared of blood and clot—in slight cases by swabbing, in severe ones by eusol, run in through a tube and siphoned off. Swabbing has advantages, but causes a great deal of shock, if prolonged.

4. The pleura having been made as dry as possible, the wound of the diaphragm is excised, and an incision about five inches long is made through the muscle (*Fig.* 101) ; its edges are then sutured to the parietal pleura and intercostal muscles all round the wound of the chest wall, so as to close the main pleural cavity completely (*Fig.* 102).

The above stages should be carried out as rapidly as possible, to lessen the risks of pneumothorax.

5. The abdominal viscera are then examined, and injuries are repaired. By this exposure the spleen can be dealt with easily, the anterior surface of the stomach and the cardia are in view, and its posterior surface can be examined by tearing through the phrenicogastric omentum; the jejunum and colon can be delivered and examined, and the kidney is within reach; if there is any difficulty, the incision is carried downwards and forwards into the abdominal wall, dividing the costal margin if necessary.

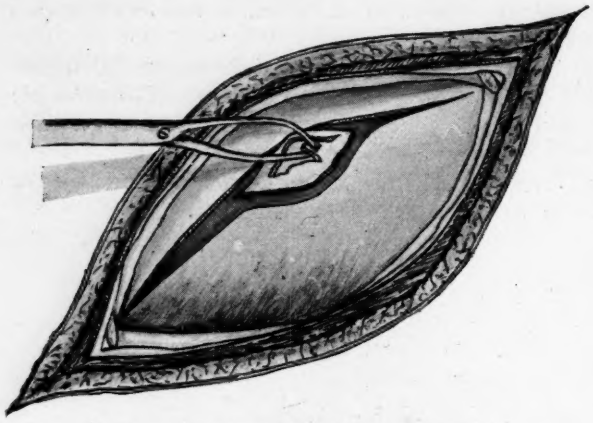

FIG. 101.—Excision of wound of diaphragm.

The wound is sutured in layers (*Fig.* 103), drainage of the abdomen being established in certain cases. It was my habit to drain the muscle layer with rubber tissue, and to insert the skin stitches at fairly wide intervals.

Suturing the diaphragm to the chest wall has certain advantages over separate suture of diaphragm and parietes independently:—(1) It ensures more secure closure of the pleural sac; (2) It allows the abdominal part of the operation to be done after the pleural cavity has been closed; (3) It permits of drainage of the peritoneum, and the muscles; (4) The costophrenic recess can be closed off from the main pleural sac, and drained, in certain cases.

If it is ever thought advisable to drain the main pleural cavity, this should be done by a valvular method, permitting air and fluid to escape but preventing re-entry.

An operation such as I have described, modified to suit the needs of individual cases, provides good access to every part of the lung, and in this way I have dealt with wounds of the spleen, stomach, liver, colon, kidney, pancreas, and small intestine.

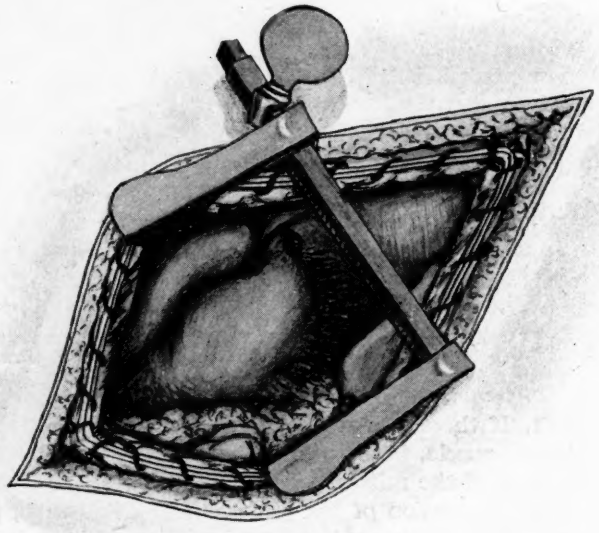

FIG. 102.—Diaphragm sutured to the intercostal muscles, closing pleural sac, and exposing abdominal viscera.

TREATMENT OF SHOCK AND RESULTS OF HÆMORRHAGE.

The Method of Anæsthesia.—An operation such as this is a severe one for a recently wounded, anæmic man, and every care must be taken to avoid additional shock; in this the method of anæsthesia is the most important consideration. Paravertebral novocain analgesia, with gas-oxygen, is the method of choice; when gas was unavailable just sufficient chloroform was given to keep the patient in light sleep, if there was a wound of the lung; otherwise, a similar stage of anæsthesia was obtained with ether. Paravertebral nerve-blocking is quicker than local infiltration of the area of operation, and is more suitable when excision of a contused and lacerated wound is the first stage of the operation. The

intercostal nerves were blocked with 1 per cent novocain, some two cubic centimetres being injected at the lower margin of each of the ribs selected, near its angle ; as many as ten nerves were blocked in some cases.

I would take this opportunity of expressing my debt to Captain Langdale-Smith and Captain W. Stott for their skilful administration of many difficult anæsthetics.

Blood-transfusion was responsible for many recoveries ; and I was fortunate in being associated for some months with Mr. Harrison, of the United States Medical Service, and his team of workers, who were available day and night for the special treatment of shock, thanks to the kindness of Dr. Crile. The blood was given usually towards the end of the operation ; this, I think, is less wasteful and perhaps more valuable than if it is carried out as a preliminary resuscitation measure ; for one thing, a patient operated on before transfusion needs less anæsthetic.

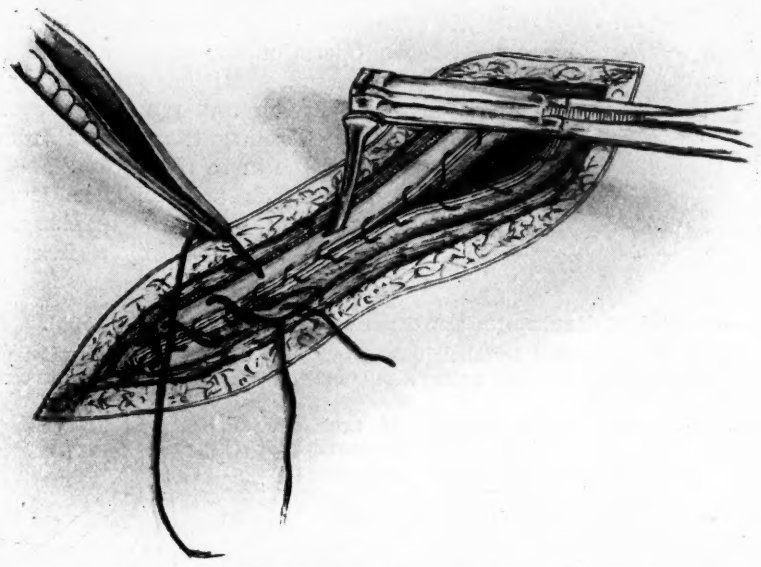

FIG. 103.—Closure of the abdomen by suture of peritoneum and muscles.

Oxygen was given during and for several hours after the operations—the only stimulant that is not valueless or harmful.

Rectal and subcutaneous saline, up to twenty pints in twenty-four hours, was used as a routine ; and for delayed ' abdominal shock ' and distention, pituitrin was given.

Varieties of Wounds of the Diaphragm.—To make an elaborate classification of wounds of the diaphragm would serve no useful purpose, but one may consider the actual wounds of the various parts of the muscle, and the associated injuries of the different neighbouring structures.

The following aspects may be borne in mind :—

1. The part affected, whether the central tendon, the right or left vault, or the margin.

2. The relation of the direction of the missile to the muscle : parallel to its surface, causing injury by in-driven fragments of rib, or producing a gutter wound ; oblique, perforating the muscle ; missiles whose direction nearly corresponds to the long axis of the trunk.

3. Complications of sepsis and hæmorrhage.

4. Associated injury of liver, spleen, pancreas, kidney, stomach, colon, jejunum, omentum, or lung.

5. Prolapse of abdominal viscera into the thorax.

Illustrative Cases.—It is proposed to give illustrations of the various types from the cases that came within my experience.

Most wounds of the *central tendon* involve the heart; such cases very rarely reached the clearing station, and those I saw were moribund on arrival. Guthrie[6] gives notes and a sketch of a wound of this area, injuring the pericardium, heart, lung, and liver; the soldier, wounded at Waterloo, died of pneumonia the following November, having suffered since the wound from "palpitations and other uneasy sensations in the chest" (*Fig.* 104).

FIG. 104.—Wound of the central tendon of diaphragm, pericardium, and left ventricle of heart (*after Guthrie*).

Contour wounds, more or less in the line of the margin of the thorax, may cause severe injury to the edge of the diaphragm without involvement of the pleura. Wounds of this type, even when the peritoneum is uninjured, repay early operation, for excision *en masse* of the wound and fractured cartilages and ribs, and suture of the diaphragm and parietes, prevent suppuration and the disability that results from a large mass of scar tissue in this situation.

In wounds at a higher level, the missile might remain above the diaphragm, but a small perforation be caused by a fractured rib driven through the muscle.

Case 31.—**Wound of diaphragm and liver by fractured rib** (*Fig.* 105).

Gunner D. J. W., wounded by shell 9.30 a.m., May 16, 1918. The missile passed through the right arm, dividing the brachial artery, and entered the chest in the mid-axillary line, fracturing the 6th and 7th ribs.

Operation, six hours later.—Wounds of arm excised, artery ligatured; wound of thorax, with fractured part of ribs, excised; projectile removed from posterior part of pleural cavity, which was then cleansed and its upper part closed by suture of diaphragm to chest wall; hole in diaphragm, due to fractured end of 7th rib, sutured; liver wound not bleeding. Wound closed, with rubber-tissue drain to costophrenic recess.

Aseptic healing of wound of thorax. Evacuated to base on ninth day, with no chest symptoms.

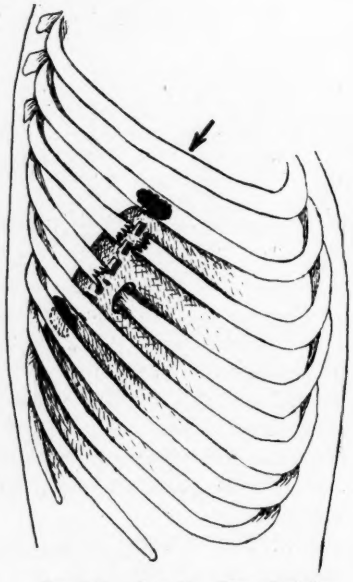

FIG. 105.—*Case* 31. Wound of the diaphragm and liver by in-driven rib.

Similar wounds fracturing several of the lower ribs were frequently responsible for severe injury of the pleura, diaphragm, and underlying viscera by indriven bone, again the missile itself not penetrating. Wounds of this type were commonly seen on the right side, left-sided ones being more rapidly fatal.

Case 26.—**Contour wound causing indriven fractures of five ribs and severe laceration of diaphragm and liver, with prolapse of omentum** (*Fig.* 106).

Pte. A. T., wounded by shell 11 a.m., March 24, 1918; extensive open wound of right lower thorax, prolapsed omentum. On admission, ten hours later, pulse 72, poor volume.

Operation, at once.—Excision of the large mass of damaged tissue, with fractured parts of five ribs, and lacerated area of diaphragm; pleura cleansed and closed; lacerated liver resected and sutured; prolapsed omentum removed; liver packed, peritoneal cavity closed off by suture.

The patient had been wounded in front of Arras on a day of the greatest anxiety to the British Army; he had to be sent to the base, in good condition, on the following day. I was unable to trace his subsequent history, but his chances were small.

On the left side, wounds of this nature may cause injury of the stomach or spleen,[7] or allow the escape of abdominal viscera into the pleural cavity.

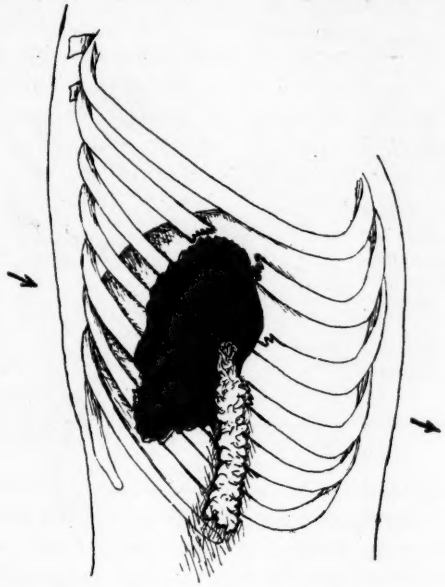

FIG. 106.—*Case* 26. Severe contour wound fracturing five ribs, with laceration of the diaphragm and liver.

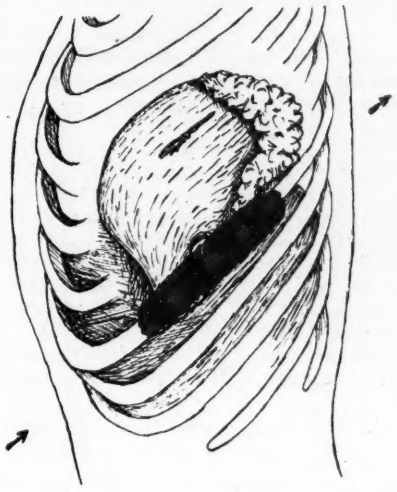

FIG. 107.—*Case* 16. Contour wound fracturing the eighth rib; prolapse of stomach and omentum through wound of diaphragm.

Case 16.—**Contour wound with immediate prolapse of stomach and omentum into pleural cavity (*Fig.* 107).**

Sapper A. S., wounded by shell Dec. 9, 1917, admitted same day with large 'sucking' wound fracturing 8th left rib; extreme dyspnœa, pulse 130.

Operation.—Wound and shattered rib excised; stomach and omentum, in which were embedded many rib fragments, prolapsed through large opening in diaphragm; stomach reduced, after suture of a laceration of its peritoneal coat, and omentum removed; inner margin of diaphragm opening sutured to intercostals, and wound closed with subcutaneous drain. At close of operation, breathing and pulse were much improved.

Third day, pulse 110, condition fairly good, but signs of extensive bronchitis in both lungs; death from bronchopneumonia on fourth day.

The man was fat and forty, and this and the cold weather were unfavourable factors.

The severity of some of these 'stove-in' wounds was frightful, but the outlook without operation was hopeless, and one hoped that occasional success might reward perseverance. It was extraordinary that some of the cases reached the clearing station and survived operation even for a short time.

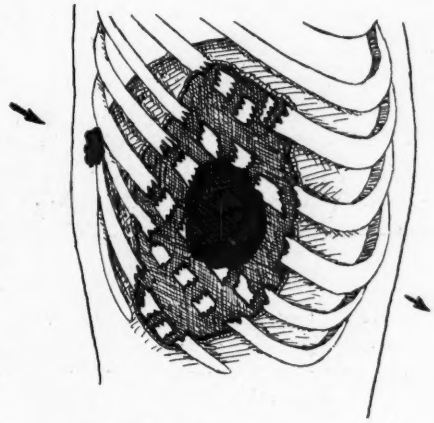

FIG. 108.—*Case* 22. Large wound fracturing six ribs and lacerating the diaphragm and liver.

Case 22.—**Large wound of right thorax, causing comminution of six ribs and severe laceration of diaphragm and liver (*Fig.* 108).**

Pte. A. G., wounded by rifle bullet 9 a.m., Dec. 29, 1917. Admitted 4 p.m., extreme collapse, wound 3 in. by 3 in., with blood, bile, and air escaping. After 700 c.c. blood transfusion, slight improvement.

Operation, at 5 p.m.—Wound excised *en masse* with several inches of six comminuted ribs; pleura closed after eusol irrigation. Laceration of liver, 10 in. long and 4 in. deep, trimmed, cleaned, packed; wound partially sutured. Death twenty-four hours later.

Missiles whose line is nearly parallel to the surface of the diaphragm may cause long cuts in the muscle, sometimes not dividing the peritoneum. This type of wound would allow the subsequent development of diaphragmatic hernia with a peritoneal sac.

Case 1.—**Gutter wound of diaphragm, with missile retained in costophrenic recess** (*Fig.* 109).

Corpl. J. L. K., wounded by shell Aug. 11, 1917. On admission, lacerated wound related to ninth left rib, left abdomen rigid, left thorax immobile. *X* rays showed left diaphragm paralyzed, and projectile related to its posterior part.

Operation.—Wound and fractured rib excised; examination showed a wound of the diaphragm 2 in. long by 1 in. wide running from before backwards. Incision prolonged forwards and downwards; examination of under aspect of diaphragm showed its peritoneum intact. Returning to the pleural cavity, a piece of shell, ¾ in. in diameter, and some cloth were removed from costophrenic recess. Diaphragm and parietes sutured, with subcutaneous rubber-tissue drain.

Wound healed by first intention, the patient being sent to the base, quite fit, ten days later.

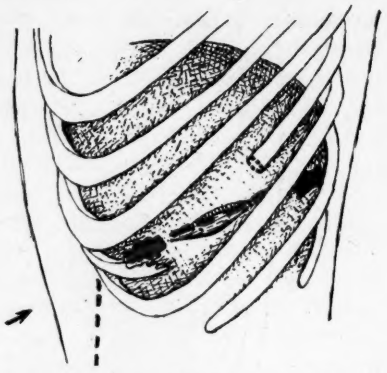

FIG. 109.—*Case* 1. Gutter wound of the diaphragm, without injury of peritoneum.

On the right side, through-and-through bullet wounds from the hypochondrium to the eighth, ninth, or tenth intercostal space usually do not need operation in the absence of bleeding which is unusual; the thoracic injury is limited to the costophrenic recess, and hæmothorax is dealt with by aspiration, which should be repeated frequently to minimize subsequent adhesions.

If, however, by a wound of this type a rib has been fractured, there is distinctly more risk of infection, which would spread from the comminuted fragments to the pleura. At the first possible opportunity, therefore, the wounded skin, muscle, pleura, and fractured segment of rib are excised *en masse*, and primary suture is carried out; in many cases of this nature I closed the pleural sac by suturing the diaphragm to the chest wall.

Through-and-through wounds due to small fragments of shell were treated on the same lines; but infection of the pleura or liver, and subphrenic abscess, occurred more commonly than in bullet wounds of this region. The following cases illustrate these varieties of sepsis.

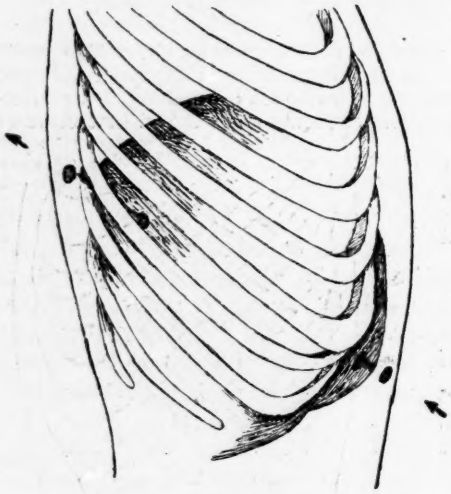

FIG. 110.—*Case* 12. Through-and-through bullet wound of the diaphragm and liver causing subphrenic abscess.

Case 12.—**Through-and-through bullet wound of liver and pleura causing subphrenic abscess** (*Fig.* 110).

Pte. C. S., wounded Nov. 30, 1917; entrance to right of lower dorsal spine, exit in right hypochondrium. Admitted in good condition, pulse 76, no sign of bleeding. Dec. 7, symptoms and signs of subphrenic abscess.

Operation. — Healed posterior wound excised through intercostal space, pleura closed, wound of diaphragm reopened, and pus and old blood lying behind liver evacuated; drainage; a fractured transverse process was felt.

After profuse discharge for some days, the condition cleared up, and the man was sent to the base, quite fit, Dec. 14, there being only slight serous discharge; no thoracic complications.

Case 14.—**Through-and-through bullet wound, exit 'sucking', followed by empyema and extraperitoneal subphrenic abscess** (*Fig.* 111).

Lieut. A. B. L., wounded Dec. 6, 1917; entrance at tenth right interspace, exit at twelfth rib, large and 'sucking'. On admission the following day, collapse and severe dyspnœa.

Operation.—Exit wound and fractured twelfth rib excised, pleura closed, track passing behind bare area of liver cleaned and drained with rubber tissue; peritoneum not opened.

Dec. 11, empyema aspirated, pneumococci identified; operation—pleura cleared of lymph and pus, valvular drainage; extraperitoneal abscess treated by two-hourly instillation of brilliant-green solution through Carrel tubes. A subsequent operation for counter-drainage of the empyema was performed, and the patient eventually recovered after a long illness with severe toxæmia.

Shell wounds of the right side of the diaphragm are much more dangerous than those due to bullets, and primary operations for the arrest of hæmorrhage and the prevention of sepsis are frequently necessary. Severe hæmorrhage from the liver was comparatively uncommon, and was usually caused by large fragments of shell.

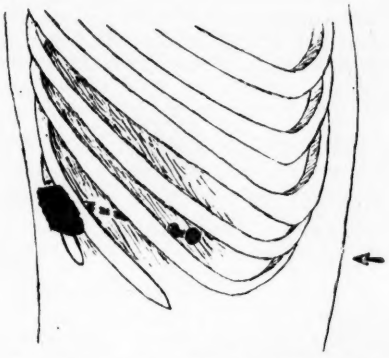

FIG. 111.—*Case* 14. Through-and-through bullet wound of the diaphragm causing empyema and extra-peritoneal subphrenic abscess.

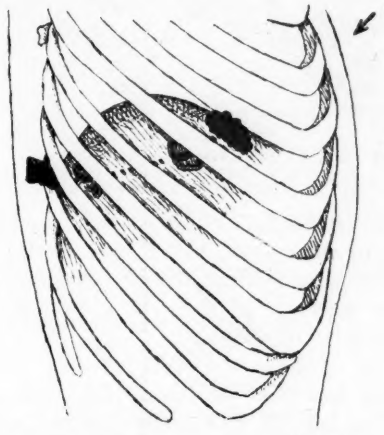

FIG. 112.—*Case* 10. Severe wound of the diaphragm and liver, with open pneumothorax.

Case 10.—**Large bleeding wound of liver, with open pneumothorax** (*Fig.* 112).

Pte. A. H. R., wounded by bomb at 2 p.m., Oct. 31, 1917; large wound 2 in. outside right nipple, which, being 'sucking', was sutured at the field ambulance. Large missile could be felt among muscles related to ninth intercostal space.

Operation, 9.30 p.m.—Entrance of sixth interspace excised and enlarged; much blood and some fragments of liver lying free in pleural sac removed; large wound of diaphragm excised, and pleural cavity closed; detached pieces of liver removed from subphrenic space; large gutter wound of liver, bleeding (*Fig.* 113); liver wound cleaned, light gauze pack, suture of parietes. Projectile and surrounding tissues excised, opening pleura at ninth interspace; sutured without drainage.

Next day, temperature 105°. Third day, temperature 102°, pulse 100, much bile and old blood discharging from drained wound. Twelfth day, patient quite fit, temperature having been normal for some days; posterior wound healed without sepsis; anterior wound clean and closed by healthy granulation tissue. Sent to base.

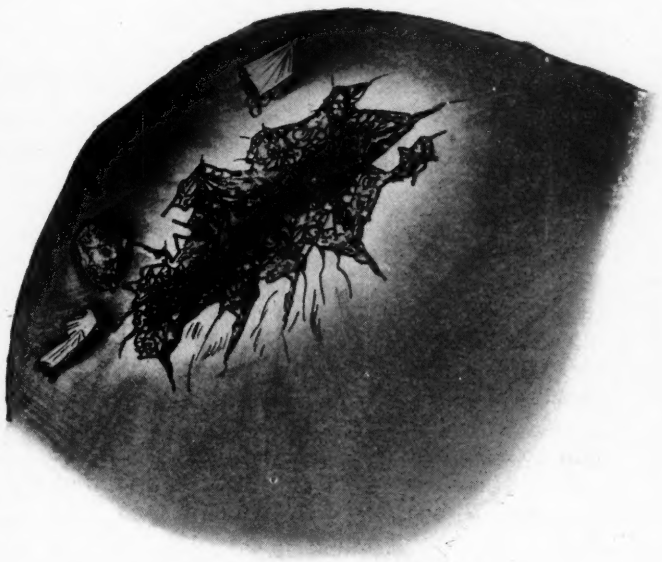

FIG. 113.—*Case* 10. Approximate representation of severe wound of the liver.

A common variety of wound was where a small fragment of shell had passed through the lower part of the thorax into the liver, and was retained; at

first I thought these cases could be treated conservatively, but experience showed that cloth was often carried in and caused acute suppuration in the liver in some cases.

Case 7.—**Abscess of liver around two pieces of shell (*Fig.* 114).**

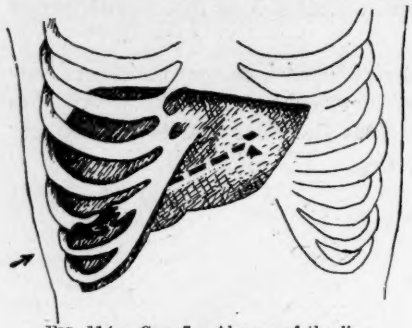

FIG. 114.—*Case* 7. Abscess of the liver around two pieces of shell.

Pte. J. F. H., wounded Oct. 26, 1917, missile fracturing anterior part of right eighth rib.

Operation, the same day.—Wound of chest wall and of diaphragm excised and sutured independently without drainage. Sixth day, wound healed, aseptic; fever, tenderness of liver. *X* rays showed two foreign bodies in left lobe of liver. On the seventh day I was asked to operate on the man, who was intensely toxæmic.

Second Operation.—Exposure by the method of Auvray; foul-smelling subphrenic abscess opened; wound entering upper and outer aspect of the liver traced through long track to abscess, containing two pieces of shell, situated in posterior part of the left lobe; abscess drained, wound sutured. Death from toxæmia the next day.

I have only on two occasions used the incision of Auvray[5], whereby a flap containing parts of the eighth, ninth, and tenth costal cartilages is turned inwards, and the diaphragm is incised below the pleural reflection line; the method gave a very good exposure of the upper surface of the liver, but it appeared to me unduly destructive of nerves and productive of shock.

As well as infection of the liver, fragments of shell retained in this organ often caused infection of the pleura and the subphrenic space, while secondary hæmorrhage into the pleura, and biliary fistula, were less frequent complications. Sir George Makins[8] has described the varieties of biliary fistula; in 7 out of 15 cases the fistula opened by way of the pleura; in one case fifteen pints of bile were removed by repeated aspirations.

Experience of such complications convinced me that it was safer to remove by primary operation every fragment of shell, bone, or cloth from this viscus. The operation is quick and simple. The thoracic wound is excised, the opening in the diaphragm is identified, and a cone of the muscle is pulled well out, so as to close off the pleural sac (*Fig.* 115); the edges of the diaphragm wound are then excised, and the muscle is sutured to the intercostals; the track in the liver is followed to the missile, and is cleansed with Volkmann's spoon and gauze after the missile and all cloth have been extracted; the wound of the chest wall is closed, with a wick of gauze or rubber tissue in the liver track.

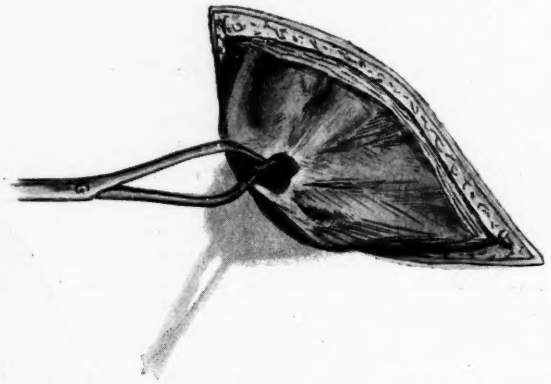

FIG. 115.—Diaphragm pulled out of the wound to close pleural sac during excision of wound of diaphragm.

Lockwood[9] advises that the liver wound be sutured and the diaphragm and chest wall be closed independently without drainage; but I think it is safer to drain the liver, and this is allowed by the method of suture of diaphragm to intercostals. A description of a typical case may be given:—

Case 20.—**Removal of shell fragment [and cloth from liver (4 in. deep) by transthoracic operation (*Fig.* 116).**

Gnr. W. R., wounded 2 p.m., Dec. 22, 1917; lacerated wound of eighth right interspace in mid-axillary line. On admission, Dec. 23, there were present dyspnœa with catch in inspiration, and frequent irritating, painful cough; *x* rays showed foreign body in liver.

Operation, 6 p.m.—Wound excised, making opening 2 in. long in pleura; wound of diaphragm excised after clearing pleura of blood by swabbing; pleura closed; track in liver explored with finger, and shell fragment and pieces of cloth removed, from 4 in. deep, with spoon; track cleaned by swabbing; gauze wick inserted to position of missile; wound sutured.

Drain removed on fifth day. Sutures removed on tenth day, aseptic healing; patient, quite fit, sent to base.

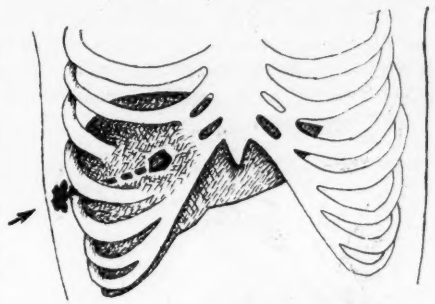

FIG. 116.—*Case* 20. Fragment of shell retained in the liver.

Severe primary hæmorrhage from the liver into the pleura is not uncommon.

Case 24.—**Severe intrapleural hæmorrhage from wound of liver due to small retained shell fragment.**

Pte. J. P., wounded Jan. 26, 1918, by small missile passing through lower intercostal space posteriorly and retained in liver. On admission, pulse not palpable, large hæmothorax, heart displaced to left. Severity of collapse precluded operation. Third day, condition improved, 10 oz. blood aspirated from pleura; seventh day, three pints of bloody fluid aspirated. Feb. 6, evacuated to base, quite fit.

Secondary hæmorrhage was not so often seen.

Case 21.—**Infection of pleura by *B. perfringens*, severe secondary hæmorrhage from wound of liver by small fragment of shell, retained.**

Pte. G. A. W., wounded 2 p.m., Dec. 27, 1917, in posterior part of tenth right interspace. On admission, severe collapse, rigidity and tenderness in hypochondrium; *x* rays showed small foreign body in liver, 6 in. from skin.

Operation, 10.30 p.m.—Wound excised, much blood removed from pleura, chest wall sutured.

Jan. 6, 1918, leaking of foul, bloody fluid from wound, *B. perfringens* found; stitches removed, pleura drained. Jan. 10, severe secondary hæmorrhage, filling pleura and escaping externally; ninth rib excised, pleura cleared of blood and closed by diaphragm-intercostal suture; light pack of bleeding liver track; 800 c.c. blood transfusion.

The patient died of collapse and toxæmia.

In this case a thorough primary operation might have been expected to give a better result.

In all cases of wound of the liver, however slight the injury might appear, there is risk of the development of a train of symptoms of extremely acute onset, followed by death in a few hours. A patient who is apparently doing well, with normal pulse and temperature, suddenly about the fourth day becomes intensely collapsed, and the pulse is not to be felt; there may be acute delirium, and the temperature runs up to 105° or more; death takes place in a few hours. In several cases the symptoms have been so acute that the nurses thought them due to severe hæmorrhage. Post-mortem examination showed no suppuration or hæmorrhage; on section the whole liver was pale except for a bile-stained zone round the wound.

The clinical condition of these cases closely resembled that seen in delayed anæsthetic poisoning, and appeared to be due rather to toxæmia from destruction of liver tissue than to infection; in several of the cases the wounds were quite slight, without laceration. I concluded that it is even more important to avoid the use of a toxic anæsthetic for patients with liver wounds than any other class.

Injury of the lung by a missile which passes through the thorax before entering the abdomen is a serious complication, but needs no special consideration here; it suffices to say that any special treatment of the lung, as for arrest of hæmorrhage, should be completed before the abdominal part of the wound is dealt with.

As to wounds of thorax and abdomen by separate missiles, there has been some difference of opinion among surgeons as to which should first be operated upon, thorax or abdomen. Sir Henry Gray[10] said the chest wound should come first; Gask and Wilkinson[11] advised first operating on the abdominal wound.

Implication of both lungs in a wound which traverses the diaphragm usually causes death. In one case of this nature I had to operate for hæmorrhage.

Case 32.—**Wound of both lungs and left kidney (*Fig.* 117).**

Pte. W. B. Bullet wound at midnight, May 17, 1918; entrance sixth right interspace, exit posterior aspect of left chest; severe hæmoptysis and hæmatemesis at once.

Operation, within twelve hours, for severe bleeding from open posterior wound.—Exit wound and four fractured ribs excised; lung adherent to pleura and bleeding freely, sutured; left kidney extensively lacerated, removed; diaphragm and chest wall sutured. The patient died the same day.

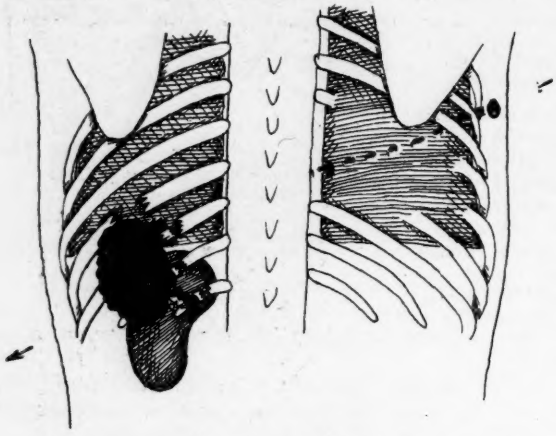

FIG. 117.—*Case* 32. Through-and-through bullet wound of both lungs and the left kidney.

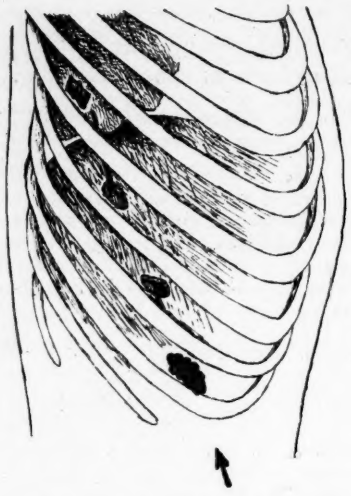

FIG. 118.—*Case* 9. Double wound of the diaphragm, missile retained in lung.

Wounds that traverse the diaphragm and then enter the lung are more serious as a rule than those passing from above downwards; of this class the most favourable are those that enter the lower part of the chest wall, pass through the diaphragm in two places, and then enter the lung.

The following case died of acute infection, the inflammation of the chest wall being apparent when the patient reached the casualty clearing station.

Case 9.—**Fragment of shell retained in lung after perforating diaphragm in two places, without injury to liver; removal of missile followed by gas gangrene of lung (*Fig.* 118).**

Lieut. C. H. H., wounded 10 p.m., Oct. 30, 1917. Entrance right ninth interspace in anterior axillary line. On admission sixteen hours later, wound inflamed, large hæmothorax.

Operation.—Wound with œdematous muscle and 6 in. of ninth rib excised; two holes in vault of diaphragm sutured; shell fragment removed from lower part of lung; lung wound cleaned and sutured; pleura cleared of clot, irrigated with eusol, closed without drainage.

Next day, intense toxæmia, temperature 104°; stitches removed, foul fluid and gas evacuated; drainage. *B. perfringens* identified. Death on fourth day.

The passage of a projectile into the thorax, after traversing the intestine, nearly always caused death; I know of no case that recovered if the missile wounded the lung after passing through intestine.

Wounds of the colon involving the pleura were specially difficult to deal with; the gut was usually loaded, and the danger of death from infection of pleura or retroperitoneal cellulitis was very great; to diminish the risk of the latter complication, so common in wounds of the ascending and descending colon, I adopted the expedient of making an oblique incision and leaving unsutured all the layers of the abdominal wall except the peritoneum. Such wounds do not gape if the patient is kept sitting up without intermission. Thanks to excellent nursing, the patient whose case is next described recovered, in spite of the fact that the pleura, peritoneum, and perinephric fat had been severely contaminated with colon contents before admission.

Case 34.—**Shell wound of right kidney, hepatic flexure of colon, diaphragm, and pleura, with fracture of rib (*Fig.* 119).**

Pte. T. H. R., wounded 10.20 a.m., May 26, 1918. On admission, 5 p.m.: Lacerated wound below right twelfth rib, missile felt at front part of sixth rib close to skin, which was punctured, and discoloured over wide area.

Operation, immediately.—Gas-oxygen, novocain nerve-block of intercostal and lumbar nerves. Excision *en masse* of tissue round foreign body, with wide area of skin, fractured sixth rib, and wound of diaphragm; distinct fæcal smell on opening pleura, and tissues excised were stained with intestinal contents; pleura closed, after irrigation with eusol, by diaphragm-intercostal suture; wound closed without drainage. Entrance wound excised and enlarged forwards and downwards to linea semilunaris; right kidney, torn right across, removed; considerable soiling of peritoneum from through-and-through wounds of hepatic flexure; colon wounds sutured; peritoneum closed; wound otherwise left open, except for two sutures to rectus sheath; Carrel tubes to abdominal wall and perinephric fat. Blood transfusion 20 oz. At end of operation, pulse 120, blood-pressure 70.

May 28 and 29, aspiration of small quantity of blood from chest. June 1, fæcal fistula. June 3, Carrel treatment stopped. June 10, fistula closed itself. June 11, chest wound healed by first intention; abdominal wound granulated to level of skin, 1 in. wide at widest part. Patient sent to base. Wrote from England a few weeks later, "Wound almost completely healed, awaiting a ship for repatriation to New Zealand".

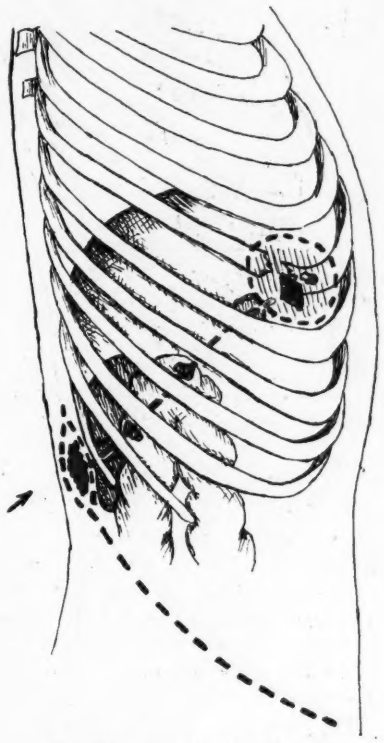

FIG. 119.—*Case* 34. Shell wound of the right kidney, colon, diaphragm, and pleura.

When the direction of a missile nearly corresponds to the long axis of the body, it may have a long course in abdomen and thorax before being arrested; in such a case, the problem that presents itself is how to obtain exposure of all the injured structures with the minimum of additional trauma to a patient already suffering from severe shock and hæmorrhage. To make separate abdominal and thoracic incisions increases the length of the anæsthetic and the number of manipulations, whereas resection of the eighth or ninth rib and incision of the diaphragm give sufficient exposure of the thorax and abdomen for most injuries; if necessary, the incision can be prolonged into the abdominal wall.

The next case illustrates these points, and is also of interest because it was the first occasion on which I performed a partial resection of the spleen; this appeared to me to be less severe than splenectomy for wounds not involving the hilum, but it would be hardly feasible by any other exposure. Splenectomy for wounds has had a high mortality, and it is agreed that the removal of this organ diminishes resistance to infection. I am not aware that partial resection has been previously carried out or advocated.

Case 41.—**Wound of spleen, diaphragm, and lung; resection of damaged part of spleen. Large projectile removed from upper lobe of lung (*Fig.* 120).**

Gnr. W. P. R., wounded 1 p.m., July 24, 1918. Large lacerated wound 6 in. to left of third lumbar spine. Six hours later, condition good; pulse 76; severe dyspnœa, left abdomen rigid, no vomiting or hæmoptysis. *X* rays show missile in upper part of lung close to heart, and large hæmothorax.

Operation, 8.30 p.m.—Pulse 84. Light sleep by chloroform on one layer of gauze, lower seven dorsal and upper three lumbar nerves blocked with novocain. Anterior 6 in. of eighth rib and costal cartilage removed, pleura opened and cleared of large quantity of blood; piece of shell, 1 by 1 by $\frac{1}{2}$ in., embedded in upper lobe of lung, removed; lung track cleansed by swabbing; lower lobe examined and found uninjured, missile having passed to its inner side; irrigation with eusol. Wound at highest point of diaphragm sutured and fixed by same stitch to sixth interspace; pleura closed by diaphragm-intercostal suture. Incision near margin of diaphragm; spleen bleeding from

severe lacerations of its lower third extending right through it in an area 3 in. wide (*Fig.* 121); resection of lower three-fifths of spleen, suture of capsule controlling bleeding; abdominal viscera carefully examined and found uninjured; bleeding omentum removed; wound closed, with rubber tissue to spleen. Wound of entry, passing up through abdominal wall to outer side of colon, excised in one piece, peritoneum sutured, rest of wound packed with 1 per cent iodoform-paraffin gauze. Pulse 92 at end of operation.

Next day, pulse 92, no dyspnœa, vomited twice slightly; third day, very fit, pulse 88, temperature remains normal; fourth day, drain removed, no inflammation of loin wound; sixth day, 15 oz. aspirated from pleura; seventh day, stitches removed, upper wound healed, loin wound appears aseptic; nineteenth day, sent to base, loin almost healed.

Went to England a few days later, and returned to his home two months afterwards, without complications.

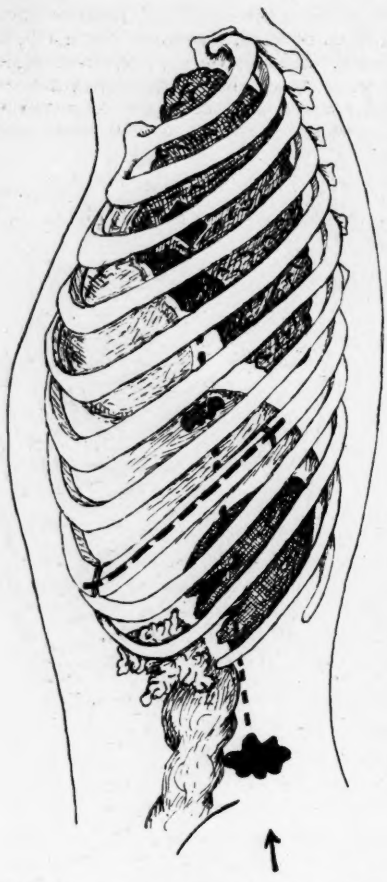

FIG. 120.—*Case* 41. Wound of the spleen, diaphragm, omentum, and lung.

FIG. 121.—*Case* 41. Extent of injuries of spleen, treated by resection of three-fifths of the viscus.

For anatomical reasons, wounds which perforate the left side of the diaphragm offer more variety than those on the right, and are often responsible for special complications requiring surgical intervention; the more important of these are hæmorrhage from the spleen, mesentery, or omentum, penetration of stomach or intestine, and escape of abdominal contents into the pleural sac or even outside the body. A wound of this side also causes more respiratory and cardiac embarrassment, from the communication between pleura and peritoneum, prevented on the right side by the liver.

Wounding of the spleen is not necessarily an indication for operation, for small missiles frequently pass through it without appreciable bleeding, and superficial glancing wounds sometimes bleed little; more commonly, however, the organ is extensively lacerated, and as a general rule it is safer to look and see than to 'wait and see'.

A case of splenic hæmorrhage that had to be treated conservatively was the following:—

Case 23.—**Severe splenic hæmorrhage associated with destruction of left arm.**

Pte. H. W., wounded by shell, Jan. 19, 1918. Admitted in extreme collapse, pulseless; left arm destroyed at level of surgical neck of humerus, attached by two bridges of skin only; missile

had struck lower ribs, and signs of splenic hæmorrhage were present ; had suffered from diarrhœa for some days previously.

Operation.—Gas-oxygen ; rapid amputation of arm through tuberosities of humerus.

Next day, flicker of pulse, uncountable, abdomen tender and distended, vomiting and absolute constipation. Third day, pulse 140, continuous vomiting, complete obstruction, abdomen rigid, dullness of flanks.

Second Operation.—Spinal anæsthesia by novocain, small incision outer part of right rectus sheath ; clot and several pints of fluid blood evacuated, rubber-tissue drain of pelvis. Patient at end of short operation pulseless ; 600 c.c. blood transfusion, pulse immediately afterwards 110.

Recovered without incident. Sent to base on fifteenth day ; arm healed by first intention, short sinus of abdominal wall.

The common varieties of wounds of the spleen were gutter wounds of the outer surface, through-and-through perforations with radiating splits of the capsule (*Fig.* 122), severe lacerations, and complete separation of a segment.

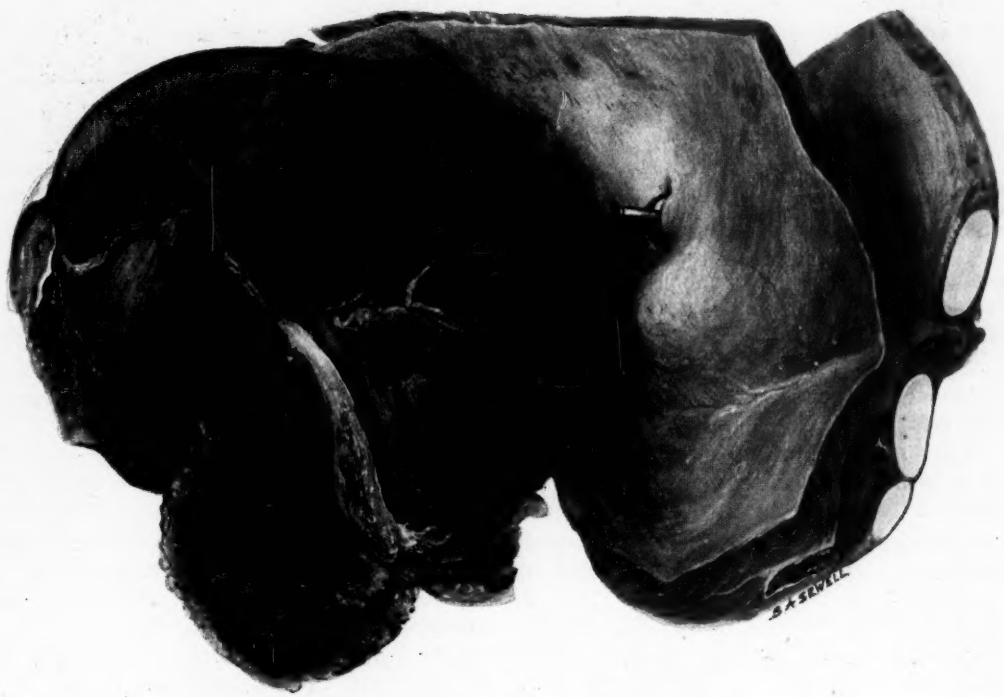

FIG. 122.—Double wound of the diaphragm and spleen.
(*Specimen* 336, *War Collection, Museum of the Royal College of Surgeons of England.*)

In my earlier cases I sutured the wounds or removed the organ ; when I realized the ease with which the spleen could be exposed by an incision through the outer part of the diaphragm, I was able to resect the damaged portion in some cases.

In many cases wounds of the spleen are associated with injuries of other viscera ; in the following case the spleen alone was injured.

Case 46.—**Wound of diaphragm and spleen ; transthoracic splenectomy** (*Fig.* 123).

H. M., German, wounded by bullet, Aug. 8, 1918. Admitted same day. Sealed entrance in left loin, exit seventh interspace, prolapsed omentum, blood escaping ; pulse 90, blood-pressure 110.

Operation.—Omentum removed ; excision of wound and 8 in. of eighth rib and cartilage ; wound of diaphragm excised ; pleura closed ; lower two-thirds of spleen lacerated into hilum ;

splenectomy, closed without drain. Gas-oxygen and novocain were employed, pulse at end being 96. There was no sign of shock. Pulse next day 96. Seventh day, little blood aspirated from pleura; wound healed, aseptic. Eighth day, evacuated to base, quite fit.

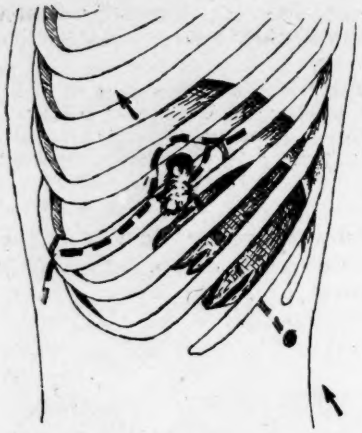

FIG. 123.—*Case* 46. Wound of the spleen and diaphragm, with prolapse of omentum.

In the next case the missile pulped the spleen and was retained in the pancreas.

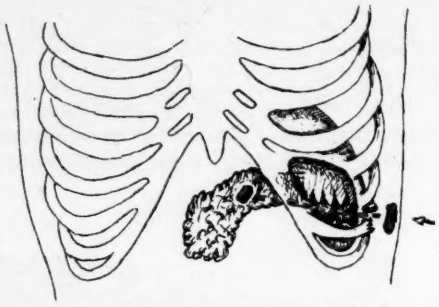

FIG. 124.—*Case* 35. Shell wound of the diaphragm, spleen, and pancreas.

Case 35.—**Shell wound of diaphragm, spleen, and pancreas** (*Fig.* 124).

Sergt. J. H., wounded 9 a.m. by shell fragment, May 31, 1918, fracturing ninth left rib in posterior axillary line; vomited at once. On admission, collapse, pulse 130, general abdominal rigidity. *X* rays show missile 1½ in. from mid-line, 6 in. deep from front, at level of wound.

Operation, seven hours after injury.—Wound and rib (5 in.) removed; omentum prolapsed in pleura reduced; wound of diaphragm excised, pleura closed; pulped spleen removed, track traced into pancreas; missile not removed; closed without drain after exploration of viscera and removal of much blood from abdomen. Blood transfusion 25 oz.

Except for one aspiration of the pleura, the patient recovered without incident, and was sent to the base about three weeks later.

In several cases severe hæmorrhage from omentum was a complication of a wound of the left side of the diaphragm, the viscera escaping injury (*Cases* 13, 43).

The stomach is often implicated in abdominothoracic wounds; it may be perforated; it may prolapse into the thorax; and in one case a gastric fistula discharged through a wound of the lung. It is often the cardiac end of the viscus that is wounded, and this region and the posterior surface are more accessible through a thoracic than an abdominal incision.

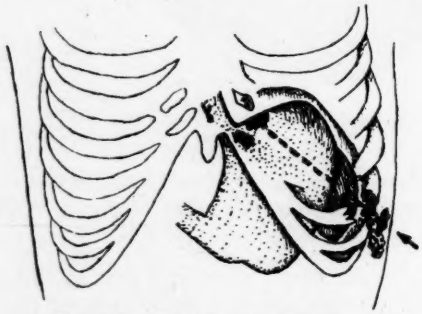

FIG. 125.—*Case* 37. Shell wound of the diaphragm, spleen, and stomach, with prolapsed omentum.

The following case illustrates the ease with which a lacerated wound 1 in. from the cardia was sutured, and the posterior surface explored, by tearing through the gastrosplenic omentum. The missile had remained in the lumen of the stomach.

Case 37.—**Abdominothoracic wound of spleen and stomach, with prolapse of omentum** (*Fig.* 125).

Sergt. L. A. P., wounded 11 p.m., June 2, 1918, fragment of shell entering seventh interspace in mid-axillary line; no vomiting. Admitted seven hours later. Pulse 108; left abdominal rigidity, catch in respiration; *x* rays showed missile related to left suprarenal body.

Operation, eight hours after injury.—Gas-oxygen, intercostal nerve-block; excision of wound and fractured eighth rib and cartilage (6 in.), prolapsed omentum reduced, diaphragm wound excised, pleura cleansed and closed. Incision prolonged to abdominal wall; lacerated wound of greater curvature of stomach 1 in. from cardia sutured, through-and-through wound of spleen not bleeding; closed without drainage after careful examination of whole of posterior surface of stomach.

No shock or vomiting; small hæmothorax aspirated on fourth day. Tenth day, stitches removed; healed except for one stitch abscess of abdominal wall. Sent to base on thirteenth day. Wrote from England in August: "Fully recovered, no complications".

Injury of the kidneys was a common complication, its seriousness depending on hæmorrhage, and later perinephric infection; the former was usually controlled by packing, occasionally by suture; in many cases lumbar or transpleural nephrectomy was necessary. These cases call for no special description. For all wounds of the kidney it is essential to drain the perinephric tissue early; when a wound of the diaphragm is also present, it is important to close it, for in many cases an opening in this muscle allowed infection to spread to the pleura.

The effects due to the actual opening in the diaphragm have already been indicated; the one most worthy of special notice is the immediate prolapse of abdominal contents into one or other pleural sac. On the right side, this complication is unusual; but portions of liver may be found lying free in this side of the thoracic cavity, and occasionally omentum prolapses.

On the left side the omentum very frequently passes through the wound of the diaphragm, and this fact forms a definite indication that all wounds of the left side of the diaphragm should be repaired by operation if the risk of late dangerous complications is to be avoided. I have already described a case of hernia of the stomach immediately after a wound of the diaphragm. The occurrence of gastric or intestinal fistula opening through the thorax is uncommon; Gaudier and Labbé[12] recorded a case of fæcal fistula of this nature which developed some six months after a wound; and in a case operated upon by Chénier[13] there was a fistula of the splenic flexure opening through the thoracic scar. A wound complicated by gastric fistula came under my observation at a period when the surgery of chest wounds had been little developed.

Case 51.—**Diaphragmatic hernia of stomach, with fistula opening through lung and wound of chest wall.**

Pte. S. E. W., admitted April 4, 1917, with leaking wound of posterior part of intercostal space of left side; vomiting and severe collapse. The general condition improved, but on the fifth day escape of gastric juice was apparent, and the condition began to deteriorate. On the seventh day I made a jejunostomy under local analgesia, but the man died on the following day.

Autopsy.—The whole of the stomach was in the left pleural sac, a wound of its posterior wall communicating with the exterior by track passing through left lung, which was adherent to stomach and parietal pleura; no sign of infection of general pleural cavity or of peritoneum.

LATE EFFECTS OF INJURIES OF THE DIAPHRAGM.

Most of the late effects which follow rupture and wounding of the diaphragm fall into three groups: (1) *The results of a foreign body embedded in the muscle*; (2) *Scarring and adhesions*; (3) *Diaphragmatic hernia.*

1. **Foreign Bodies Embedded in the Muscle.**—In 1917, Patel[14] reported a series of cases in which he had removed foreign bodies from the diaphragm. Of 64 missiles retained in the thorax, 25 were embedded in the diaphragm; all these were successfully removed by an extrapleural route.

Symptoms.—The most prominent symptom produced by a projectile embedded in the diaphragm is fixed pain, which is exaggerated on exertion, and is sometimes referred to the clavicle or scapula; it is produced especially by the effort of lifting, by coughing, and by deep respiration. Some patients complain of attacks of suffocation, due presumably to the foreign body being in contact with one of the phrenic nerves; in others an irritating cough is brought on by every deep respiration. The patient learns to keep the diaphragm immobile on the affected side, and as a rule this provides the only physical sign.

Diagnosis.—This depends on localization by *x* rays. The depth of the missile is measured, and the fact of its being embedded in the muscle is shown by the extent and direction of its movements during respiration; if in the anterior portion near the parietes, the direction of movement is that of the thoracic wall and the converse of the movement of the diaphragm; if the foreign body is in the anterolateral part of the muscle, it is displaced vertically on respiration as well as moving in a lateral and anteroposterior

direction; if it is attached to the central tendon, it undergoes wide vertical excursions, and the movements of the heart are transmitted to it; while in missiles situated posteriorly no movement takes place.

TREATMENT.—In removing missiles from the front part, Patel made an incision close to the xiphoid cartilage; to approach the anterolateral region a subcostal incision was made, resecting a costal cartilage and stripping back the pleura after dividing the triangularis sterni, if met with; for missiles embedded posteriorly, either the lateral route was used, or an incision was made near the spine, the twelfth rib being sometimes resected. By the extrapleural route one foreign body, 14 cm. deep, embedded in the central tendon close to the right wall of the pericardium, was removed through an incision close to the lower part of the sternum, a triangle of costal cartilage being resected.

Phocas[15] described, in 1917, a case of removal by the transpleural route of a fragment of shell embedded in the diaphragm near its highest part on the left side; and of the 49 retained projectiles whose removal from the chest Sir Berkeley Moynihan described to this College last year,[16] one was embedded in the diaphragm and removed through the pleural sac.

Since we have had so much experience of open transpleural operations, this method seems to possess no particular dangers, and it allows the release of pleural adhesions which are often responsible for some of the symptoms.

2. **Scarring and Adhesions.**—Adhesion of a scar of the diaphragm to the chest wall, and to the viscera in relation to it above and below, appears to cause a definite disability; I have had the opportunity of seeing several men who had been wounded years previously by missiles traversing the muscle. Objective signs were slight, but the train of symptoms was very similar in all cases, and it appears that involvement of the diaphragm in a scar is a considerable handicap to a working man.

SYMPTOMS.—There is pain on exertion, situated in the region of the wound, the lower part of the thorax and the upper part of the abdomen on the injured side, and just below the clavicle. Pain below the clavicle is specially severe when the abdominal muscles are fixed in lifting weights. In some cases there is præcordial pain and palpitation, due presumably to extrapericardial adhesions of the left costophrenic sulcus.

An instance of these symptoms is the case of W. B., who was wounded on March 2, 1918, by a bullet which passed through the right side of the diaphragm horizontally from front to back. In August, 1920, he was complaining of severe pain in the lower part of the right chest, the right hypochondrium, and below the clavicle, brought on by fast walking or running, by any exertion which involved forcible contraction of the abdominal wall, and by drinking large quantities of fluid. The lower lobe of the lung had evidently been collapsed and had failed to re-expand completely; the symptoms appeared to be due to adhesion of the diaphragm to the liver and to the parietal pleura.

McDougall[17] investigated the late results of chest wounds in a large number of cases, and he agrees with other observers as to the definite disability resulting from intrathoracic adhesions, particularly those passing from diaphragm to chest wall. Grey Turner observed that patients suffer more from pain and tenderness when there is a localized area of adhesions than when there is general diffuse adhesion of the pleural surfaces, and Moynihan's[16] experience confirms this.

Many soldiers have complained of gastric symptoms subsequent to a wound of the chest, especially loss of appetite, and vomiting. These symptoms may be due to immobility of the diaphragm, adhesions passing from it to abdominal viscera, and sometimes to a communication between pleural and peritoneal cavities.

DIAGNOSIS.—The presence of adhesions involving the diaphragm can be demonstrated by *x* rays, typical appearances being alteration of its regular contour, absence or limitation of movements, and obliteration of the costophrenic sulcus.

Undoubtedly diaphragmatic hernia is a more common sequela of wounds of the left side than has been realized, and many cases have been overlooked. There is danger of diagnosing adhesions alone in patients whose symptoms are really due to hernia, and this condition should always be suspected in men complaining of pain and attacks of vomiting if there is a possibility of the left side of the diaphragm having been wounded.

I saw recently a pensioner, H. B., who was wounded in the left thigh by a rifle bullet on August 14, 1915. There were two scars below the left iliac crest; the lower one was circular; the other, immediately above it, was vertical and about 2 in. long. The wound had always been considered to be a superficial one of the through-and-through type. There was no sign of bone or muscle injury, but the man was complaining of pain in the chest, cough and expectoration, palpitation on exertion, and shooting pain under the heart; he was thin, pale, and cachectic, with a pulse-rate when resting of 120. Rhonchi were heard in the lower part of the left lung. I suggested an *x*-ray examination, and this showed a bullet in the left chest, just above and outside the apex of the heart.

The military history of this man is interesting, for he was sent back to duty overseas six weeks after being wounded, and he remained with the army abroad until April, 1919; he succeeded in gaining admission to hospital for two months in 1917, and for two and a half months in 1918, the diagnosis of bronchitis having been made on the first occasion, and pyrexia N.Y.D. on the second occasion. I saw him because he was appealing against an inadequate pension.

I have mentioned this case because the significance of wounds of this type is apt to be overlooked.

Treatment.—As to the treatment of pleural adhesions involving the diaphragm, their separation during operations undertaken primarily for the removal of foreign bodies has seemed to play an important part in the relief given to the patients; but it is a question if thoracotomy is a justifiable operation for adhesions alone, especially as the most difficult position from which to clear them is the costodiaphragmatic sulcus. The operation itself is not dangerous, but it is difficult to ensure a perfectly dry pleura at the end, and in some of the recorded cases empyema has followed, causing fresh adhesions.

MacMahon[18] has recommended a deep breathing exercise to get rid of adhesions between diaphragm and chest wall, the patient lying supine and the operator pulling strongly on the fully abducted arms at each inspiration; but it is difficult to believe that exercises can do much, except perhaps in quite early stages.

Another late complication of an abdominothoracic wound is due to infection of the lung or of an abdominal viscus in which a missile is retained. Dr. Willy Meyer[19] gives details of a case of abscess of the liver around a bullet which had entered through the thorax six weeks before; he operated successfully through an incision of the eighth intercostal space. Many of the cases recorded by Moynihan had a focus of infection of the lung around the projectiles which he removed several months after the receipt of the wounds.

3. **Diaphragmatic Hernia Resulting from Injury.**—By far the most important of the late results of wounds and other injuries of the diaphragm is due to the persistence of a communication between the pleural and peritoneal cavities, or to the stretching or rupture of a scar of the muscle. I have already mentioned that it was known very many years ago that wounds of the diaphragm rarely heal, and it seems likely that as a result of the recent international and civil wars there are now living a larger number of men suffering from diaphragmatic hernia than at any previous time.

The experience of recent years has clearly shown that in some instances, at any rate, wounds of the diaphragm do heal spontaneously, for well-healed scars have been seen at subsequent operations; in Meyer's[19] case the wound of the right side of the muscle had healed, and Greig[20] saw the healed scar of a wound of the central tendon some years after it had been inflicted. The truth seems to be that small wounds, especially if due to bullets, and incised wounds, particularly those of the right side or the central tendon, do heal with a sound scar; on the left side, small wounds sometimes heal, but usually they are closed by the adhesion of stomach, spleen, or omentum. Large wounds of the right side are closed by the liver, to which their edges may become adherent; large wounds of the left side remain open—a source of great danger.

Time of Onset.—Prolapse of abdominal viscera sometimes takes place within a few hours of the diaphragm being ruptured or wounded, but it is much more common for the onset of symptoms of diaphragmatic hernia to be delayed for several months. There has been considerable discussion on the question of how long after the injury the hernia

usually occurs, and in most of the recorded cases the early symptoms have been so insidious that it has been impossible to put a date to their commencement; when we consider the various anatomical and pathological factors, it is clear that the interval between the injury and the onset of hernia must vary widely in different cases.

Sometimes the first symptoms have followed a sudden strain or prolonged effort. In a case recorded by Ware,[21] the patient stated that he vomited everything for the first fifteen days after the receipt of an abdominothoracic wound, and from the same date suffered from severe constipation; in a case of Dr. Soresi,[22] on the day following a wound the patient, after a severe fit of coughing, had a sensation of choking by something pressing on the inside of the chest and abdomen, and he then vomited food taken thirty-eight hours before. Barton[23] described a case where, about five months after being wounded, the man, who had been sent back to France, vomited every day after his first long march, and continued to do so for nine months; in other cases the symptoms have dated from a sudden effort, particularly lifting a heavy weight. Gaudier[24] considered that, in cases of insidious onset, prolapse of omentum preceded the colon and stomach.

Pathology.—It is said that diaphragmatic hernia may result from an opening caused by empyema or subphrenic abscess; but this variety appears to be extremely rare.

The original injuries have been most commonly the result of bullet or shell wounds, but in some ardent races knife wounds of the diaphragm are not uncommon; Cornea[25] recorded 45 stab-wounds of the diaphragm, 7 of which were due to a stab of the fourth and fifth interspaces. Cases following simple rupture from run-over injury are met with from time to time.

Traumatic diaphragmatic hernia is very much more common on the left side; hernia of omentum into the right pleural sac sometimes occurs, but does not lead to serious consequences; very rarely hernia through the central tendon into the pericardium has happened. The commonest position for the hernial orifice is in front of and lateral to the œsophageal opening, sometimes continuous with it, sometimes separated from it by a band of atrophied muscle. In the very great majority of cases there is no true hernial sac, and the term prolapse would be more strictly correct; but a peritoneal sac is sometimes present, limiting the size of the protrusion. The edges of the opening may be sharp-cut and fibrotic, or they may be unrecognizable, the muscle gradually thinning into a fibrous layer incorporated with the surface of the prolapsed viscera. The former is more common, as the result of a wound which has never healed, or of the giving way of a scar; the latter is probably due in some cases to the gradual stretching of a healed scar.

The viscera most commonly prolapsed are the stomach, transverse colon and splenic flexure, the spleen, and the jejunum, in order of frequency, and the omentum is included in nearly every case; occasionally the duodenum, the pancreas, and the liver have been involved.

The herniated viscera become adherent to the margin of the opening and to the thoracic contents. Adhesion to the pericardium and the parietal pleura is usual; adhesion to the lung is less common. These adhesions are often very firm, and constitute the most serious difficulty in treatment. In some cases, however, the organs form no attachments even to the diaphragm.

The stomach becomes dilated and hypertrophied, and in some cases, of which examples have been given by Warren[26] and by Gaudier and Labbé[12], the sharp edge of the opening has produced an ulcer of the stomach. The heart is displaced to the right, usually only to a slight extent; the lung is collapsed and compressed, and occupies the upper part of the thorax. I have already mentioned examples of gastric and intestinal fistula complicating diaphragmatic hernia.

Strangulation of the hernia is a frequent complication, and in many cases the condition has not been suspected until its discovery at an operation for acute obstruction. Dr. Ameuille[12] (mentioned by Gaudier and Labbé) had a case of intestinal obstruction due to the splenic flexure of the colon being alone strangulated in a diaphragmatic hernia.

SYMPTOMATOLOGY.—The cases can be divided into two main classes: (1) Those presenting symptoms of chronic diaphragmatic hernia, subject to recurrent exacerbations; (2) Cases suffering from acute obstruction and strangulation.

1. *Chronic Type.*—There probably exist a number of unrecognized cases in which a very small part of the stomach is herniated through the diaphragm as a result of an old wound. Soresi[22] has called attention to the probability that very small congenital herniæ are not uncommon. It is evident that if we can diagnose cases while the prolapse is comparatively small, the dangers and difficulties of cure by operation are much diminished.

The symptoms of a small diaphragmatic hernia of the stomach and omentum are not very definite; but the occurrence of heartburn, loss of appetite, and pain after meals, palpitation, vomiting, dysphagia, dyspnœa, abdominal or thoracic pain on exertion, wasting and constipation, in a man whose scars indicate a possible injury of the left side of the diaphragm, should be viewed with grave suspicion, and he should be examined systematically with *x* rays, and kept under careful observation. The recorded cases of prolapse of a large portion of the stomach into the thorax have been sufficiently numerous to enable a fairly definite clinical picture to be described, and in many instances in recent years a definite diagnosis has been made before operation.

It is interesting to read Guthrie's[6] descriptions of patients presenting chronic symptoms, and others with acute strangulation of diaphragmatic herniæ following wounds received at the time of Waterloo. For strangulation he suggested laparotomy, though he had not actually carried it out.

The chronic cases fall into three classes: those in which abdominal symptoms predominate; those with marked respiratory distress; and those whose chief complaint is cardiac embarrassment. The majority belong to the first class. The symptoms vary with certain factors, depending on which viscera are prolapsed, how much of them is affected, their relation to thoracic contents, adhesions, and the nature, size, and position of the defect of the diaphragm.

Abdominal symptoms.—The implication of the stomach in nearly all cases is responsible for the most prominent symptoms. These may be almost entirely subjective, and one is impressed by the number of cases recorded in which the sufferers have been looked on as malingerers The case described by Barton[23] is typical of many; here the soldier's complaints had been disregarded for months, and he was repeatedly sent back to duty, until he became extremely wasted and ill and was delivered into the hands of the surgeon.

Pain is a prominent symptom; it may be situated in the epigastrium, the lower abdomen, the affected side of the chest—specially below the clavicle—or in the shoulder (a symptom first mentioned, I think, by Guthrie[6]). Præcordial pain is sometimes present. The pain comes especially very soon after any food or drink, and is in many cases so severe that the patients have taken nothing but a small milk diet for months; it is relieved by vomiting, and increased by exertion, especially weight-lifting. Occasionally it has been noted that the pain goes at night, when the patient lies down; sometimes it is relieved by lying on the left side (Rowlands[27]) or on the right side; in Sir Charters Symonds' case,[28] when, during acute exacerbations, the patient would sit upright with his back flexed, straightening of the back caused acute pain. There may be a sense of great distention after food, referred to the inside of the chest and abdomen, and sometimes described as a feeling of acute suffocation.

Vomiting is a most important symptom, and is increased by exercise; it occurs soon after meals, and to some extent relieves the pain and distention. Often the patients are unable to retain any solid food, but can take fluids; in Ware's[21] case cold fluid food could alone be retained, even warm drinks being vomited. The vomit may contain bile, and in some cases altered blood has been noted. A most valuable clinical observation in regard to the vomiting was described by Gaudier and Labbé[12]: the patient, who was extremely emaciated, could only retain fluids, and it was noticed that he did so much more easily when lying; by making practical use of this fact, keeping him recumbent before and after meals, his general condition improved and he was able successfully to

undergo a severe operation. It has since been recorded in several instances that vomiting and pain are prevented by avoidance of the upright position during and after meals, and this constitutes, perhaps, the most typical single symptom of diaphragmatic hernia. Looking through notes published in the past, one sees it mentioned from time to time that symptoms abated at night, or were worse in the latter part of the day; but the application of these observations to treatment was not realized; in fact Guthrie[6] made the theoretical suggestion that in suspected cases the patients should be warned to remain erect for some time after each meal, and always to avoid stooping.

In some cases there has been *dysphagia*, but this is commoner in the congenital variety of hernia.

Constipation is almost invariable, and has often preceded other symptoms, with a liability to attacks of complete obstruction.

As a result of the pain, vomiting, and constipation, most cases show *emaciation*, *anæmia*, and *cachexia*, and they are usually nervous. The wasting may be very gradual, for patients learn to confine themselves to milk taken at frequent intervals.

The respiratory symptoms are pain on deep breathing and dyspnœa on exertion. Sometimes there are attacks of suffocation, especially in the evening.

The cardiac symptoms are palpitation and præcordial pain.

There may be recurrent attacks of pyrexia.

The objective evidence of the condition may be very slight, but most cases present some of the following signs:—

Abnormal flattening or retraction of the abdomen, and on palpation a sense of emptiness of the epigastrium and left hypochondrium. The abdomen is as a rule relaxed, but sometimes there is localized rigidity and tenderness on deep pressure. The stomach resonance may extend to a level well above the nipple. The movements of the left side of the thorax are diminished, and fullness of this side of the chest may be obvious.

Various abnormal chest signs have been noted by different observers. In the case described by J. Grant Andrew[29] the base of the left lung was dull, the respiratory murmur being absent in the lower half of the lung. Not uncommonly the breath-sounds are faint, and accompanied by gurglings and borborygmi of amphoric note; these sounds are sometimes perceptible to the patient at each respiration, especially towards evening or after meals; splashing sounds can be elicited by moving the patient during auscultation of the epigastrium.

Signs due to the close relation of the stomach to the pericardium are not very prominent, apart from a persistent tachycardia increased by exertion or meals. The heart is usually slightly displaced, as indicated by the position of its right border; the apex beat in most cases is in normal position, but diffuse, and the heart may present irregularities of rhythm. Tinkling sounds are sometimes produced by the impulse of the heart on the stomach; these may be perceptible to the patient, and may be heard by the surgeon on auscultation of the left chest.

2. *Acute Obstruction and Strangulation.*—This is a condition of great danger, and the recorded cases of recovery are not numerous, partly because of the pre-existing emaciation, but chiefly because, owing to the difficulty of diagnosis of this rather rare condition, most of the cases have reached a desperate state of exhaustion before operation.

In recording three cases, upon two of whom he operated, Mr. Richard Warren[26] stated, in 1919, that of seven cases of diaphragmatic hernia admitted to the London Hospital, five were of the traumatic variety; five were admitted for acute obstruction, and one recovered.

The typical picture is one of acute obstruction with an empty abdomen. The patients are thin and very ill, with severe pain, continuous vomiting, and absolute constipation; excessive thirst is often complained of. The abdomen is usually retracted and hollow, without rigidity or tenderness; sometimes, however, there is tenderness, and in one of Warren's cases there was a resonant pear-shaped epigastric tumour, which gave splashing sounds on palpation,

In the chest there may be splashing on respiration, and tinkling corresponding with the heart-beats.

DIAGNOSIS.—In the chronic stage the cases have been most often mistaken for pyloric obstruction. Confirmation of the diagnosis of diaphragmatic hernia is to be obtained by *x*-ray examination, but a glance at the literature of the subject shows that not infrequently the findings have been negative, even when a large part of the stomach was above the diaphragm. These cases have been diagnosed as pneumothorax, and even the use of opaque emulsion has not led to a correct conclusion in all cases; it is clear that if the cardia and pylorus are in the abdomen the emulsion may be seen to pass below the diaphragm without entering a pouch of the fundus. The *x*-ray appearances may closely resemble those of hour-glass stomach due to other causes; in one of the cases cured by Soresi,[22] at a previous operation a piece of shell had been extracted from the vicinity of the lesser omentum, and an omental band had been divided in the belief that it was producing the constriction.

However, in recent years the technique of the *x*-ray examination of these cases has been carefully studied, and many detailed descriptions of methods and results have been published.[30, 31]

The comparison of the position of a single scar of entrance with the localization of a retained missile may give a clear indication of injury of the diaphragm. Simple radiography may show an opaque area to the left of the heart shadow, irregularity of the diaphragm, and displacement of the heart to the right. But it is from the use of radioscopy with the swallowing of bismuth or barium emulsion that the clearest evidence is obtained. Repeated examination may be necessary, and in a small hernia of the stomach considerable manœuvring may be called for to get the emulsion into the thoracic pouch. The patient is examined upright, facing the observer, and turned to both sides in turn; he is then screened in the supine, prone, and lateral positions; failing a positive result, he is placed in the Trendelenburg position, and again turned in the various directions. Sometimes massage of the abdomen and deep respiration have been successful in bringing a small hernia to view; such pouches close to the œsophagus must not be mistaken for congenital œsophageal pouches.

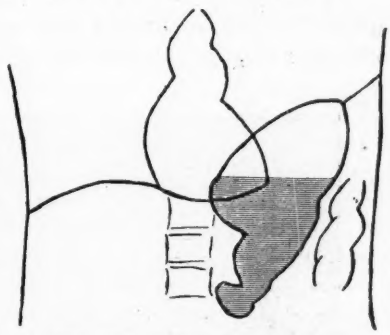

FIG. 126.—Radioscopic appearance of a diaphragmatic hernia of the stomach, after opaque meal (*after Baumgartner and Herscher*).

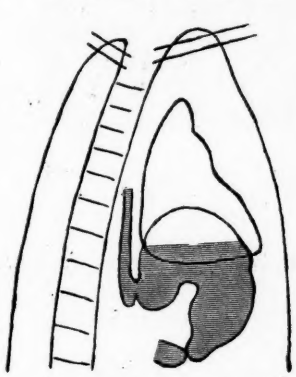

FIG. 127.—Oblique radioscopic view of a diaphragmatic hernia of the stomach after opaque meal (*after Baumgartner and Herscher*).

The appearances seen on repeated examinations of two cases of Baumgartner and Herscher[32] serve as an illustration of the methods; the first diagram shows the condition seen after a barium meal, the patient upright and facing the observer; the stomach is above the level of the diaphragm, its lower part being occupied by emulsion, its upper part by air, above which the curved outline of the stomach is seen (*Fig.* 126). The next view is an oblique one, showing two abdominal pouches and an intermediate thoracic one (*Fig.* 127). At another examination in the

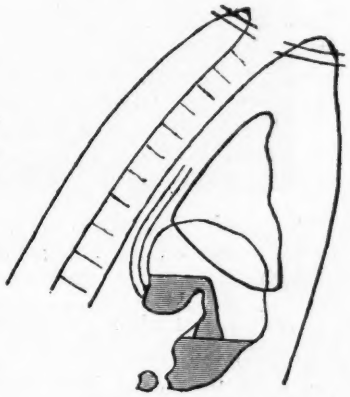

FIG. 128.—Oblique radioscopic view of a diaphragmatic hernia of the stomach; on the patient bending, the opaque emulsion is seen cascading from upper to lower pouch (*after Baumgartner and Herscher*).

oblique position, sufficient opaque emulsion to fill the first pouch was given; on the patient bending forwards, the barium was seen to fall as a cascade into the lowest pouch (*Fig.* 128).

In another case two pouches were shown; at each inspiration the barium flowed into the upper one, returning on expiration to the subdiaphragmatic part of the stomach. Splashing of the surface of the fluid could be seen produced by the movements of the heart (*Fig.* 129).

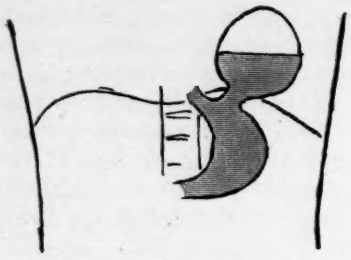

FIG. 129.—Radioscopic view of a diaphragmatic hernia of the stomach (*after Baumgartner and Herscher*).

Radiographs published by Ware[21] show the appearances after an opaque meal with the patient upright and supine (*Figs.* 130, 131). When the colon is involved, it may be made apparent to *x* rays by giving an opaque enema.

PROGNOSIS.—Strangulation eventually occurs in most cases, unless operation is undertaken. Many successful operations have been performed in the quiescent stage, but Greig[20] has suggested that recurrence may be commoner than is supposed; so far there is little evidence bearing on this point, as most of the cases have been operated on in comparatively recent years.

TREATMENT.—Little can be done apart from operation; but in some cases the general condition of the patients, and especially the existence of chronic bronchitis in elderly men, has prohibited active surgery.

FIG. 130.—Radiograph of diaphragmatic hernia of stomach, patient upright (*after Ware*).

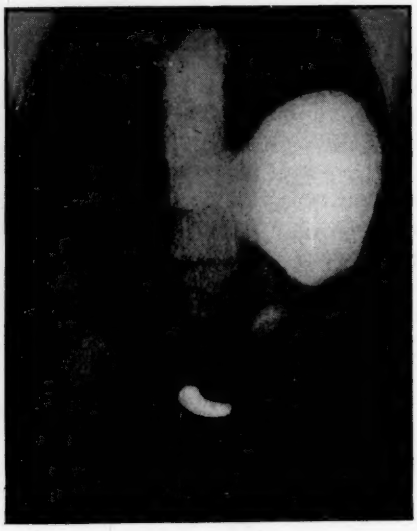

FIG. 131.—Radiograph of diaphragmatic hernia of stomach, patient supine (*after Ware*).

Such patients must be warned against exertion and sudden strains, their meals must be small, and they should lie down afterwards.

The operative procedures fall into three groups:—(1) The abdominal method; (2) The thoracic method; (3) The combined abdominothoracic method.

1. The most commonly employed abdominal incision is one placed close to the costal margin; a manœuvre which increases the exposure is to divide the costal margin. A high left paramedian incision joining a transverse one at the level of the umbilicus, the left rectus being divided, gives a good exposure (*Fig.* 132).

2. The thoracic route of approach has come into increasing favour since war has

provided surgeons with so much practice in chest surgery. A portion of the sixth, seventh, or eighth rib is resected; by removing all the rib in front of its angle a good view is obtained.

3. The first description of the employment for diaphragmatic hernia of an incision opening abdomen and thorax together was apparently given by Bérard.[33] The incision is made over the seventh, eighth, or ninth rib, and continued forwards and downwards in the abdominal wall; the rib is resected and the costal cartilage divided. I have used this method on many occasions for dealing with the results of abdominothoracic wounds, and it seems the most suitable for difficult cases of diaphragmatic hernia. Probably the best course is to commence by resection of the rib, prolonging the incision to the abdomen later if it proves necessary (*Fig.* 133).

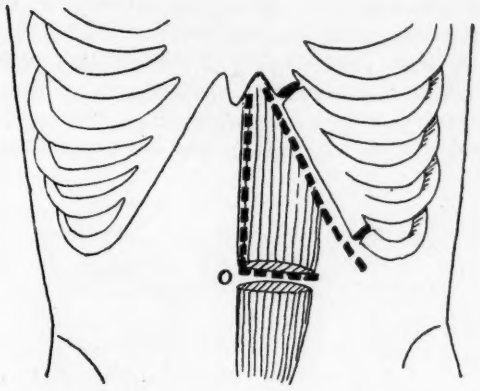

FIG. 132.—Abdominal incisions used in operations for diaphragmatic hernia.

Methods less commonly used are to turn down a flap containing part of the eighth, ninth, and tenth costal cartilages (corresponding to the liver incision of Auvray), and a vertical incision in the mid-axillary line, resecting several ribs. The objection to both these procedures is the extensive division of nerves and vessels that they necessitate.

There has been a good deal of discussion of the relative merits of the abdominal and thoracic methods. The main objections to the thoracic route seem to be that surgeons are more practised in abdominal than in thoracic surgery, and that secondary conditions—for instance, gastric ulcer and adhesions—may necessitate intraperitoneal procedures such as gastrojejunostomy.

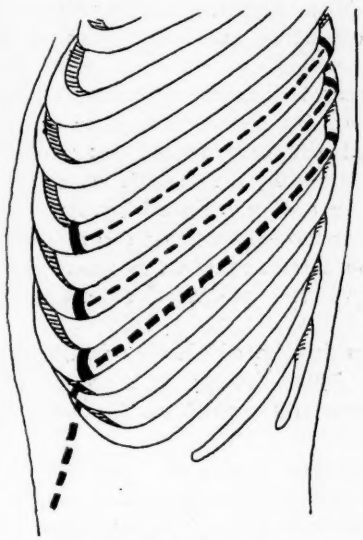

FIG. 133.—Thoracic and abdominothoracic incisions for approach to a diaphragmatic hernia.

The abdominal incision will be used for most cases dealt with in the acute stage, for they come to surgeons as abdominal emergencies, and as a rule their exact nature is only discovered during the operations. The presence of a scar of the chest wall may have suggested the correct diagnosis, but the patient is usually unfit for systematic radioscopy. In most of these cases emaciation and complete obstruction, with empty intestines, make access to the diaphragm fairly easy from below.

In a chronic case dealt with in a comparatively quiescent stage, however, the thoracic method, or the abdominothoracic one, offers considerable advantages; it allows a clear view with less retraction of the parietes, and the diaphragm can be repaired more adequately than by the abdominal route.

Stages of Operation for Diaphragmatic Hernia.—After opening the abdomen or thorax, the stomach, omentum, and other prolapsed viscera must be freed by dividing the adhesions; this must be done with the minimum of dragging, by clean cutting rather than blunt dissection. These adhesions, especially of hollow viscera to pericardium, and of spleen to thoracic wall, may be very dense, and care must be taken to divide them in such a way that, if important structures are injured, they shall be those most easily repaired; naturally it is better to open the stomach than the pericardium or colon.

The defect in the diaphragm may be very difficult to define, the whole of the left side of the muscle being atrophic and the margin of the opening incorporated with the stomach wall. In some cases of long standing, adhesions have been so dense, particularly of the stomach and spleen, that it has been considered unwise to attempt their separation. In the case recorded by Baumgartner,[32] the diaphragm was reduced to narrow ledges in front and behind, the stomach was firmly adherent to the posterior margin of the opening, and the outer surface of the spleen was fixed to a scar of the thoracic wall; through an abdominothoracic incision the surgeon freed the small intestine, omentum, splenic flexure, and stomach from the pericardium and front part of the diaphragm, leaving intact the adhesions of the spleen and of the back of the stomach; he then adopted a manœuvre used previously by Lecène, closing the defect by suturing its edges

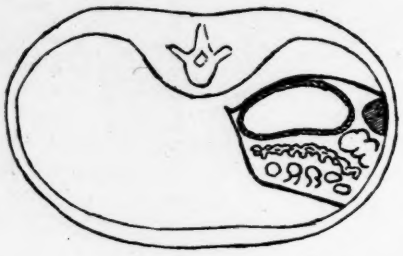

FIG. 134.—Diagram of contents of a diaphragmatic hernia.

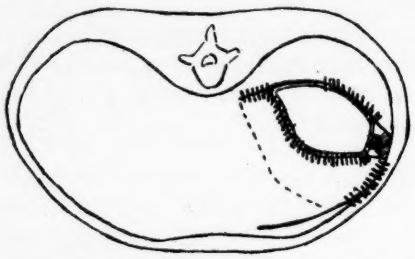

FIG. 135.—Method of suture to close defect in the diaphragm (*after Baumgartner and Herscher*).

to the stomach and to scar tissue at the lower part of the spleen (***Figs.* 134, 135**); the result was very satisfactory, and radioscopy six months later showed the stomach below the diaphragm and the lung re-expanded (***Fig.* 136**). In the successful case reported by Grant Andrew,[29] he found it necessary, operating through the abdomen, to divide the omentum and leave part of it attached within the thorax.

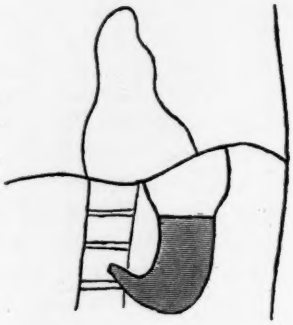

FIG. 136. — Radioscopic appearances six months after cure of a diaphragmatic hernia (*after Baumgartner and Herscher*).

A dangerous step of the operation is the reduction of the stomach into the abdomen, for its contents may be forced into the œsophagus and flood the only sound lung; this disaster was probably responsible for the death of a case operated upon by d'Hallopeau[34] and mentioned by Auvray. Auvray recommends that the thoracic pouch of the stomach be emptied by aspiration before its reduction is attempted, a safeguard only possible if the thoracic exposure is employed.

Careful closure of the gap in the diaphragm is important, and is more easily done from above; in most of the cases operated on from below for strangulation, the surgeon has had to make use of a simple purse-string suture. A most thorough method of suturing has been described by Soresi,[22] who points out that the constant movement of the diaphragm during healing, and the outward pull of its fibres, put a great strain on the suture-line. He advocates a series of separate stitches inserted parallel to the margin of the opening; the adjacent ends of each two sutures are then tied together, and the gap is closed by tying these ends across it. Greig[20] stitched the inner edge of the opening to the chest wall; some of the stitches gave way during subsequent coughing, and a second operation was performed with eventual success. In repairing a defect of the outer part of the diaphragm, Lefort[35] made successful use of a graft of fat and deep fascia taken from the thigh.

The last stage of the operation is the closure of the abdomen and thorax, after paying careful attention to hæmostasis; if, in rare circumstances, it is thought advisable to drain the pleura, a valvular method which allows fluid and air to escape but prevents their re-entry should be employed.

Conclusion.—We may conclude then that in operations for strangulation and acute obstruction the abdominal route will be employed as a rule.

In chronic cases, the thoracic method of approach has certain advantages; it allows thoracic adhesions to be divided under better observation, with more safety, and easier control of bleeding points; the herniated pouch of the stomach can be emptied before reduction; accurate suture of the diaphragm and any plastic measures that special conditions demand can be carried out more satisfactorily; and the pleural sac can be cleansed and its dryness at the end of the operation ensured.

If special difficulties arise, or a gastrojejunostomy is indicated, the thoracic operation should be converted into an abdominothoracic one by prolonging the incision.

In all types of operation the pleural cavity is open to the air, so that the slight risks of operative pneumothorax are equally present.

I wish to express my thanks to Mr. S. A. Sewell for the drawings of *Figs.* 121, 122, 130, and 131; to Professor J. Ernest Frazer for help with some of the other diagrams; and to Mr. Warren Low, C.B., for permission to use the notes of a case.

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SKIN-GRAFTING IN THE BUCCAL CAVITY.

By T. P. KILNER and T. JACKSON, Sidcup.

The intention of this paper is to deal in full with one branch of technique which has been evolved at the Queen's Hospital, Sidcup, during the treatment of facial injuries in the last few years.

In March, 1917, Esser described in the *Annals of Surgery* a method of skin-grafting which he had employed in the treatment of distorted eye-sockets. This method was modified and its field of usefulness greatly extended by Waldron and Gillies, and its various modifications have been in almost daily use for some time now by surgeons operating upon those cases of facial injury which have formed such a pitiable harvest of the Great War.

Gillies' book, recently published, contains a brief description of the technique followed; but it is felt that a wider use of the method might be made than is at present the case by surgeons and dental surgeons who are unlikely to have that book in their possession.

The paper will be divided into two parts: (1) A brief outline of cases to which the method is applicable; and (2) A description of the technique.

I. CASES IN WHICH THE METHOD IS APPLICABLE.

A.—Cases in which the External Alveolar Sulcus is Absent, or Deficient in Depth.

War Injuries.—It is in this class of case that our experience has been greatest. Numerous cases of facial injury involving the mouth, and frequently associated with fracture of the maxilla or mandible, have been encountered, in which the most troublesome residual disability is entirely dependent upon distortion or complete obliteration of the sulcus between the lip or cheek and the alveolus.

Bulky masses or bands of scar tissue between the soft tissues and the bone render the fitting of an efficient functional denture impossible. Such a disability is seen at its worst when the jaws are edentulous, for every movement of the cheek or lip displaces the denture from its already insecure bed.

Parallel Cases met with in Civil Practice.—In ordinary civil practice quite a large number of cases analogous to these war cases is encountered from time to time. As our experience of these is extremely limited, we shall do little more than point them out.

The similarity is, however, so close that their treatment by the same procedure cannot but give similarly satisfactory results.

Excessive Absorption of the Alveolus.—Cases of this type are particularly common in dental practice. A recent visit, however, to the out-patient department of a general hospital revealed the fact that they are met with in surgical clinics also. Two cases presented themselves in as many days complaining of ulceration of the gums and constant trouble with dentures, in which the source of trouble was easily traceable to the deficiency of the external sulcus, due in turn to unusually marked alveolar absorption. No definite dental ridge remains in these cases; numerous attempts are made to fit a denture, but neither comfort nor utility can be obtained; every movement of the jaw, tending still further to reduce the depth of any sulcus remaining, displaces the denture, and the patient is reduced to a state of desperation. Such a condition is the bane alike of patient and dental surgeon.

Fræna.—Abnormally thick labial fræna are sufficiently common to find themselves illustrated in every book on dental surgery, as a cause, particularly, of central incisor displacements. Similar mucous-membrane-covered bands occur in other situations, and, though not as a rule interfering with dentition, and therefore not giving trouble in the first half of life, are very trying when the fitting of a denture is under consideration. The ordinary treatment of these bands—division or even excision—is frequently followed by recurrence or by the formation of a soft papillary mass of scar tissue which renders such treatment ineffective. Treatment by the method here advocated, though a little more troublesome, has all the advantages of being certain and radical in its results.

Scar Tissue.—Resulting from burns or scalds, or following ulceration produced by acids or caustics.

Scar-tissue Bands.—Following upon the rupture of an alveolar abscess in the region of the sulcus.

Deficiency of the Sulcus above and in front as the Result of Hare-lip.—Such a deficiency is almost always present in spite of every effort, at the time of original operation, to free the soft tissues well from the bone. It would be impracticable, in such young subjects and under the conditions of tension already present, to introduce anything capable of preventing the recurrence of these adhesions, and their treatment is therefore usually not considered until dentures are required. A great cosmetic improvement may be obtained by their treatment at an earlier date.

B.—Cases in which the Internal Alveolar Sulcus is Defective.

War Injuries.—It is remarkable how few even of the severest types of facial wound involve the tongue, yet quite a number of cases has been encountered in which wounds of that organ itself or of the adjacent floor of the mouth have led to the obliteration of the sulcus on the inner aspect of the alveolus. In these cases even a carefully-fitted denture is constantly being pushed off the dental ridge by tongue movements during mastication or articulation.

Parallel Cases in Civil Practice.—Cases analogous to the above are few. Occasionally, however, an unusually short and thick lingual frænum gives trouble in the manner indicated, more especially when the lower jaw is edentulous. The rare cases of ordinary congenital tongue-tie are probably best treated by the simple operation of division at present practised.

We hesitate to recommend the use of grafts in potentially cancerous areas, but throw it out as a suggestion that, in cases which have been successfully treated for carcinoma linguæ, or in which a portion of the tongue has been removed for less dangerous disease or for injury, articulation might be considerably improved by freeing of the remaining portion to some extent and epithelialization of the raw surfaces by the technique here described.

C.—Other Conditions in which the Method is Applicable.

Trismus.—This condition, depending upon the presence of scar tissue in the mucosa lining the cheek, has been met with occasionally in military practice, and might conceivably be found in cases coming under one of the above headings.

In such cases, though the sulcus is not actually at fault, treatment follows the same lines, and consists essentially of the removal of all scar tissue and its replacement by sound healthy epithelium. We have treated two cases in this way, and have obtained a measure of success much greater than we had anticipated. In one of these, previous excision of the coronoid process, adhesions of which to the adjacent maxilla were thought to be responsible for the condition, had been carried out without giving any relief.

After Removal of the Maxilla.—The deformity which follows upon this operation can be rendered practically negligible if surgeon and dentist will combine forces. As a rule, at the end of the operation there is not a very great extent of raw surface remaining; but a mould, designed in the way advocated for grafting and carrying grafts when neces-

sary, inserted at the end of the operation—preferably by the dentist who is to have the after-care of the case—not only prevents the deformity of the face which commonly follows the delay in instituting prosthetic treatment, but is also very efficient in preventing post-operative hæmorrhage.

After Tonsillectomy.—It would appear that grafting of the raw surfaces shortens convalescence, diminishes post-operative hæmorrhage, and prevents cicatricial contraction. The pillars of the fauces are sewn together loosely over a skin-graft-covered mould of suitable size and shape.

2. DESCRIPTION OF TECHNIQUE.

The method consists essentially of: (*a*) Producing a sulcus wherever this is required by careful and free excision of offending tissue; (*b*) Epithelialization of this new sulcus by means of skin-grafts of the Thiersch variety applied to its surfaces upon a suitable mould. The operative treatment may be carried out under either local or general anæsthesia; but the latter, administered if practicable by the naso-intratracheal route, is preferred. If, however, the former is chosen, the inferior dental or infra-orbital branch of the fifth is blocked, according as the sulcus under treatment is lower or upper; local infiltration of the actual area of operation is carried out; and the area from which the graft is to be removed is similarly treated. The latter procedure does not interfere at all with the vitality of the graft, and actually facilitates its removal.

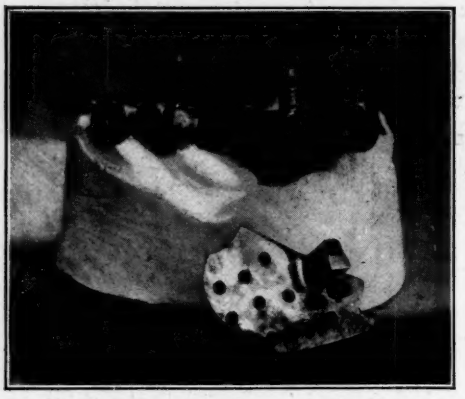


FIG. 137.—Dental splint for epithelial inlay to external alveolar sulcus.

Preliminary Dental Work.—This consists in the provision of suitable means for retaining the mould in position, and differs according to the type of case.

a. External or Internal Sulcus: Teeth present (*Fig.* 137).—A metal cap splint is made, carrying opposite the centre of the offending area an upright pillar, on to which is fitted a small tubular piece of metal provided with a screw, and having a flat perforated malleable plate projecting from it at right angles, which is directed inwards or outwards in reference to the alveolus according as internal or external sulcus is under treatment. This plate is usually from $\frac{1}{2}$ to $\frac{3}{4}$ in. in width, and its edges are neatly rounded. When a gap in the teeth is present, as is usual in traumatic cases, a bar is placed between the caps fitted to those teeth bordering upon the gap, and a vertical metal plate is attached to this and made to fit snugly against the gum-margin along the gap. This effectively prevents the mould material from escaping laterally, and so helps much in obtaining a good, smooth, and easily-removed mould.

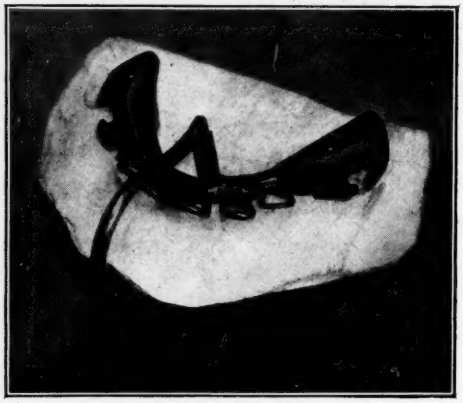


FIG. 138.—Chin-piece splint for lower sulcus in edentulous case.

b. Edentulous Cases.—These cases are difficult to treat, and a considerable range of ingenious devices has been evolved in the dental department. Suture of the mould in position alone—a method tried in order to evade the necessity for fixation apparatus—is unsatisfactory, for even if successful as a

means of retention, it produces an unsightly and troublesome ridge around the margins of the grafted area. In addition it renders the after-treatment difficult, there being no means of retention available once the sutures are out. The illustrations show the appliances now usually adopted for upper and lower alveolar regions. *Fig.* 138 illustrates a chin-piece apparatus which has been found useful for some cases in which the lower sulcus was under treatment. *Figs.* 139 and 140 represent an apparatus similar to Kingsley's splint, but provided with metal loops to carry the mould material. *Fig.* 141 shows a modified double Gunning splint which may be adapted for either the upper or lower sulcus.

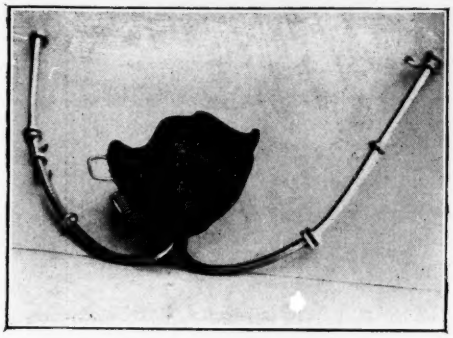


FIG. 139.—Modified Kingsley's splint for inlay to upper sulcus in edentulous case.

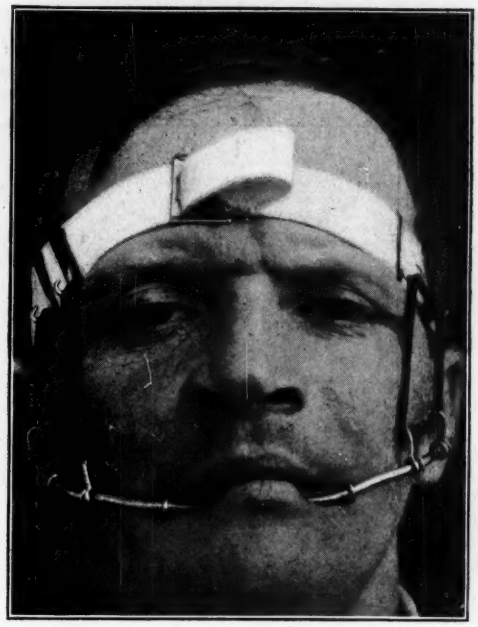


FIG. 140.—Splint *in situ*.

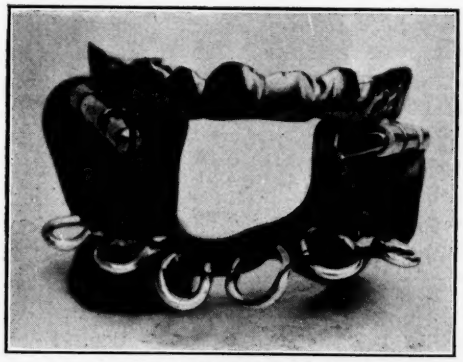


FIG. 141.—Modified double Gunning splint, which may be used for either sulcus, prepared for lower sulcus in a case with edentulous mandible.

c. Trismus Cases.—The type of apparatus (*Fig.* 142) devised for these cases provides for adjustment to the maximum gape obtainable at the time of operation, and after excision of all scar tissue. It also carries a perforated metal plate, to the outer side of which is packed the mould material which is to bear the graft. The mould should be of sufficient size to produce bulging of the cheek. In this way an excess of epithelialized surface is obtained.

FIG. 142.—Type of apparatus used in trismus cases.

d. After Excision of the Maxilla.—In these cases the dental officer who is to have charge of the post-operative prosthetic treatment should be allowed access to the case for the purpose of obtaining an impression of those parts which are to be left behind on the unaffected side. He will then construct a partial upper plate carrying metal loops to support the mass of dental composition, which, at the end of the operation, is moulded into the large gap left by the maxillary excision.

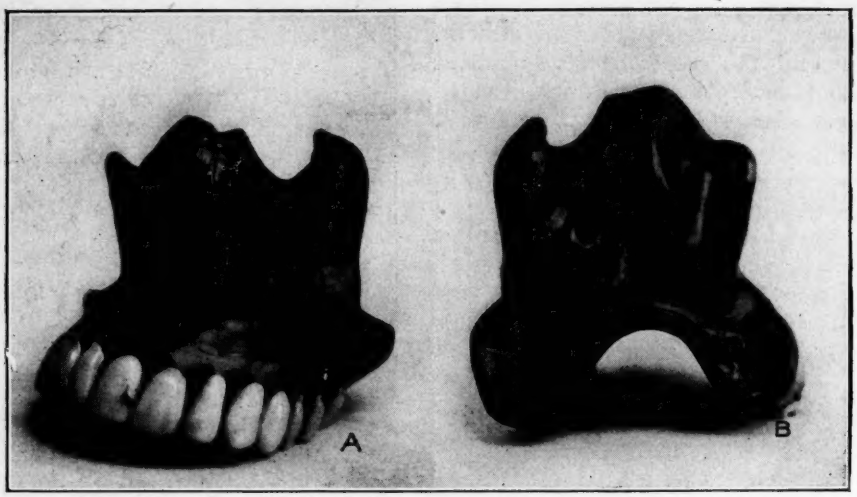


FIG. 143.—Prosthesis built up to replace excised maxillæ. A, Anterior view; B, Posterior view.

Fig. 143 shows a prosthesis built up, according to the suggestions put forward above, from a mould inserted at an operation undertaken for the removal of almost the whole of both maxillæ, which had been completely separated from their bony attachments as the result of a severe wound of the face. It is included because it indicates clearly how the same procedure may with advantage be adopted in civil cases.

Preparation of the New Sulcus.—In order to render the description of operation more concise, an outline of the procedure followed in dealing with a typical case of loss of lower sulcus will alone be considered. It will be easily seen how this is modified for other positions. *Fig.* 144 shows the state of affairs encountered.

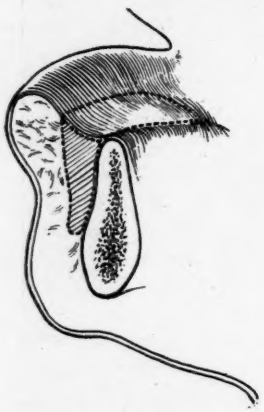


FIG. 144.—Drawing to show total obliteration of lower sulcus. Dotted lines indicate excision of scar tissue.

The dotted lines indicate the incisions made for excision of the scar tissue. It is to be noted that the inner incision is made to follow accurately the surface of the bone. This is a point of great importance, for otherwise a spongy mass of tissue is left behind on that aspect of the alveolus which the operation aims at making free for the dentist's use. Such a mass is very troublesome and renders accurate impression-taking impossible. Again, it will be noticed that the new sulcus is produced by *excision*. Mere incision into the scar tissue will, when its sides are grafted, produce a sulcus, but such a sulcus invariably tends to become obliterated by the continued growth of scar tissue stimulated by operation. The tissue included within the dotted lines is completely removed, and any hæmorrhage is arrested by sponge pressure. Ligatures are seldom required.

Making of the Mould.—An impression of the new sulcus is now made in ordinary dental-impression composition, rendered soft by sterile water at the required temperature. The detachable portion of the retention apparatus is placed in position until the material

cools and hardens. It is essential that a smooth, well-rounded impression should be obtained, and the lip or cheek should be manipulated with this end in view while the composition is setting.

Cutting the Graft.—The graft is taken from a non-hairy portion of the skin—the anterior aspect of the forearm or the antero-internal aspect of the upper arm being usually employed. At one time the skin, sterilized by ether only and moistened with saline, was held on the stretch between two pieces of wood applied transversely to the limb, and the graft was cut by a sharp razor similarly moistened with saline. This method of fixing the skin is clumsy, requires an assistant well versed in the technique, and, owing to 'bellying' of the area between the pieces of wood, often results in a poor graft of uneven thickness.

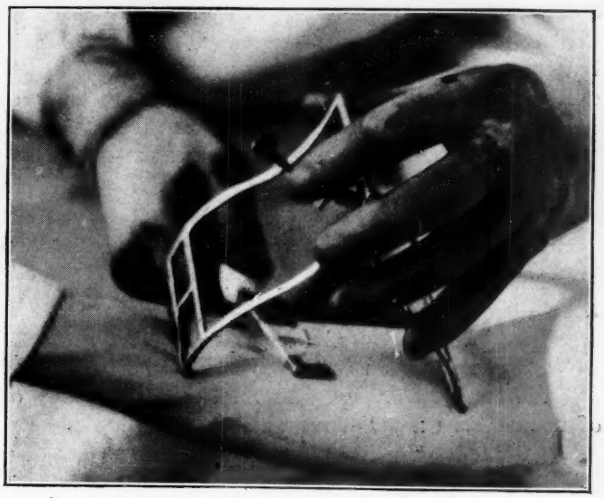


FIG. 145.—Skin fixation apparatus used in cutting grafts.

Lately we have been using the apparatus shown in *Fig.* 145, and have found it simple and reliable. The small teeth on the cross-bars get a firm grip of the skin on either side of the area to be used; gentle pressure from above, pressing these bars apart, produces even stretching with a minimum of 'bellying'; and the ratchet locks the apparatus at the desired degree of tension.

A mere touch on the upper part of the instrument with one hand steadies it, and the other hand is free for cutting. We feel that some similar instrument should be of considerable help to surgeons who wish to render their graft-cutting more certain and uniform.

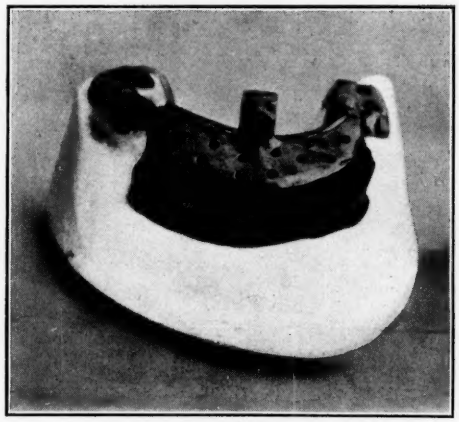


FIG. 146.—Plaster model showing splint and mould in final position.

Applying the Graft to the Mould.—The mould, removed from the mouth, is dried, and the graft or grafts are applied to it so that the raw surface is outermost. If several grafts are required they are arranged so that their adjacent margins just overlap one another. The thinner the graft, the easier it is to manipulate at this stage, and the better, in our opinion, is the final result. Any redundant graft is removed by sharp scissors, for loose tags in the mouth become septic and are liable to be pulled upon by tongue movements and so displace the remainder. The graft-covered mould is now returned to its bed, and the fixation apparatus is finally adjusted. *Fig.* 146 shows a plaster model illustrating splint and mould in their final position.

After-treatment.—The arm is dressed with ambrine, and rapidly epithelializes again—never giving any trouble after the first dressing. The mould is not disturbed for ten days. At the end of this period, during which antiseptic mouth-washes are used at frequent intervals, more particularly after meals, the retention plate is removed and the mould taken out with care. The newly-epithelialized sulcus is gently irrigated with a mild antiseptic lotion, and a new mould of guttapercha is fixed in position.

At this stage it often appears that the graft has not 'taken', for the surface may appear still raw and tend to bleed slightly, even in cases which prove to be perfectly satisfactory later on. After two days more the same procedure is repeated, with the exception that the mould is not renewed. After this the sulcus is irrigated daily, usually by the patient himself. The mould is kept in position until the dentist is ready to replace it by his denture. It is surprising how rapidly the newly-formed sulcus will become obliterated in the early stages of its existence unless some mould is retained. Later on this tendency disappears entirely, and patients are returning to us now for further treatment who were operated on twelve to eighteen months ago, and who exhibit perfectly epithelialized sulci with no tendency whatever to diminution of their depth.

In conclusion, it may be remarked that success is only to be obtained by close co-operation between surgeon and dentist—a co-operation which has been found absolutely indispensable at Sidcup.

SUMMARY.

Numerous cases of war wounds have been encountered in which the alveolar sulcus has been obliterated.

Efficient functional dentures cannot be provided.

Many analogous cases appear from time to time in civil practice.

All can be effectively treated by the method of skin-grafting here advocated, the field of usefulness of which remains still incompletely explored.

SHORT NOTES OF RARE OR OBSCURE CASES.

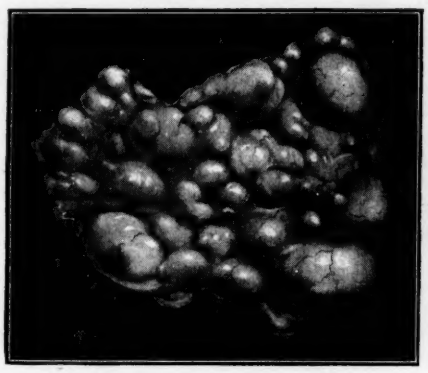
CYSTIC ADENOMA OF THE BILE-DUCTS.

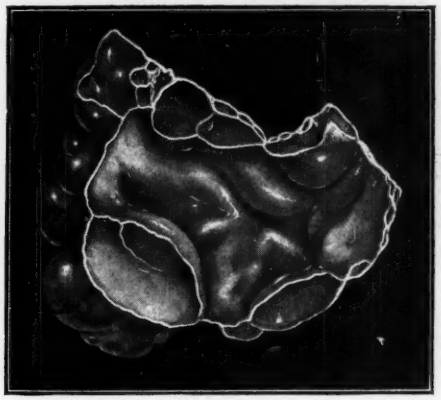
By ARTHUR EVANS, London.

The patient, a married woman, age 53, was admitted into Westminster Hospital, Nov. 20, 1919. She had ten children, and had had one miscarriage.

Following influenza in November, 1918, she had suffered from pain in the upper abdomen, with occasional attacks of vomiting, and slight jaundice. There was no history of hæmatemesis, nor of melæna. The patient was constipated.

On admission the patient was emaciated and looked ill; she was slightly jaundiced. She complained of constant pain in the upper abdomen. The edge of the liver was palpable below the right costal margin. Apparently continuous with this, and extending into the epigastrium, was a smooth rounded tumour which reached almost to the umbilicus. The tumour was dull on percussion, and appeared to be fixed posteriorly. There were no abnormal physical signs in the lungs. The temperature and the pulse were normal.





Figs. 147, 148.—One cluster of the small cysts which were detached from the inner wall of the large liver cyst.

Urine.—

1. Cammidge reaction: osazone crystals found.
2. Amylase reaction: D. 38° 30″ = 13 units.
3. Cammidge reaction after 24 hours' fermentation: typical small Cammidge crystals seen. Control negative.

Test meal.—Over 200 c.c. recovered from stomach. Faint trace of HCl present. Lactic acid present. Estimated in terms of HCl: acidity due to HCl, 0·02 per cent; total acidity, 0·1 per cent; acidity from organic acids, 0·08 per cent. Solid matter: Starch, fat, débris, squamous cells, yeasts, torulæ. No marked excess of bacteria; no sarcinæ; no Oppler-Boas bacilli seen.

Fæces.—No reaction for occult blood. No pus found. Moderate amount of fat. Microscopically: food débris, granular detritus, bacteria; no pus or blood.

Blood.—

1. Leucocyte count: total 13,700 per cmm. Polymorphs: neutrophils, 75 per cent;

eosinophils, 1 per cent = 76 per cent. Monomorphs: large, 5 per cent; small, 18 per cent = 23 per cent. Transitional, 1 per cent.

2. Wassermann reaction: negative.

OPERATION.—Dec. 1, 1919.—Median supra-umbilical laparotomy. Free fluid of a myxomatous nature was found in the peritoneal cavity. The tumour proved to be a large thick-walled cyst attached to the under surface of the liver. It was so large and tense that one's fingers could not be inserted between it and the vertebral column. When opened, a large quantity of viscid fluid escaped. The examining finger felt what were at first thought to be daughter cysts attached to the inner wall; but these proved to be so intimately adherent to the cyst-wall that clusters of these cysts could be detached only with great difficulty.

FIG. 149.—Microscopical section of the cystic mass shown in *Figs.* 147, 148. Note the well-formed, non-ciliated, mucin-secreting, columnar cells which line the cysts. The stroma consists of coarse fibromuscular tissue.

The attachment of the cyst to the under surface of the liver was fully six inches in all its diameters, and to attempt its complete removal was considered unjustifiable. The greater portion of the cyst-wall and its contents were removed; and into the remaining portion of the cyst a large rubber drainage tube was sutured.

The patient made an uneventful recovery. A sinus has persisted, and from this some clear viscid fluid constantly drains.

PATHOLOGICAL NOTES (Dr. J. A. Braxton Hicks).—The fluid was semi-gelatinous, dark brownish-green in colour. The deposit showed red corpuscles, degenerated leucocytes, cells and clumps of cells of an endothelial type. No scolices or hooklets were seen. Some of the free cells stained in a fresh specimen presented a peculiar appearance. They possessed a well-defined clear ectoplasm, and a granular endoplasm. In the endoplasm were oval parasitic-like bodies giving dark granular staining with methylene blue. Repeated examinations proved these to be merely degenerations of the columnar mucin-forming cells of the cyst tumour.

When the cystic mass was received in the laboratory it looked not unlike a small piece of a multilocular ovarian cyst (*Figs.* 147, 148). Sections showed the tumour to be made up of cysts lined with well-formed non-ciliated columnar cells, which could be seen secreting mucin. The interstitial tissue supporting the cysts consisted of coarse fibromuscular tissue (*Fig.* 149).

The tumour is a multilocular cystic adenoma arising from the bile-ducts.

This condition is very rare. Only one case has hitherto been reported in England, by Walker Hall and Brazil.[1] Keen[2] and Ziegler[3] describe and illustrate similar cases.

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A CASE OF SPLENOMEDULLARY LEUKÆMIA.

By R. E. KELLY, Liverpool.

The extraordinarily interesting paper on the surgery of the spleen by Sir Berkeley Moynihan in the last number of the British Journal of Surgery prompts me to place on record the following case. I offer it as a further example of the changes seen in the blood and bone-marrow in association with splenic disease. In addition, the case seems to present some curious features: (1) A marked amelioration of symptoms after a course of *x*-ray treatment to the spleen; (2) A spontaneous fracture of the jaw; (3) Associated 'myelopathic albumosuria'.

The patient, Mrs. X., was sent to me by Dr. E. W. Lewis, of Southport. She is 52 years of age, and, until the present illness, has been fairly healthy but never robust. There is nothing apparently pertinent in the family history. She has two children, 21 and 10 years old respectively.

Eleven years ago, in February, 1910, she began to suffer from anæmia, and was diagnosed as a case of splenomedullary leukæmia. She was ordered a complete rest, and at the end of a year she says she "was in fair condition except for the anæmia and the enlarged spleen". One doctor stated that in February, 1911, "there were many myelocytes in the blood", and another doctor, in May, 1911, that "the hæmoglobin was over 70 per cent, the red cells 3,800,000, with obvious and considerable leucocytosis".

In November, 1912, she was sent to Dr. Thurstan Holland for *x*-ray treatment for the condition; and I am indebted to him for the following notes.

"Duration of the enlarged spleen about two years. Spleen well over the mid-line. Splenic notch above and to the right of the umbilicus. Lowest border 7 cm. below the level of the umbilicus.

1912, November and December,	11	exposures	to spleen.
1913, January to December,	27	,,	,,
1914 ,, ,,	10	,,	,,
1915 ,, ,,	9	,,	,,
1916, January to May 26,	2	,,	,,

Each dose was about 1 S. with a tube of medium hardness, but filtered through three layers of thick felt.

Blood-counts: Nov. 29, 1912	Reds 3,400,000	Whites	72,000.
Dec. 29, 1912	,, 2,160,000	,,	80,000.
Jan. 15, 1913	,, 4,900,000	,,	7,000.
Mar. 11, 1913	,, 3,904,000	,,	7,000.
Nov. 11, 1913	,, 4,600,000	,,	5,900.

Spleen: November, 1912, after three treatments, spleen a good deal smaller.

December 13, 1912: Spleen well over to the left side. Then follow many records of 'rapid diminution of the spleen'.

December, 1913, spleen not to be felt.

1916.—Patient perfectly well. Spleen not felt.

The same note on May 26, 1916, when all *x*-ray treatments were stopped."

Dr. Holland also saw the patient in June, 1919. His note runs: "Quite well. Good colour. Spleen normal in size".

To return to the patient's own narration. At the end of 1916 she felt perfectly well, her blood-counts were normal, and she could walk ten miles with comfort.

For over three years she remained apparently perfectly well.

In July, 1920, she noticed that she was more easily tired. A little albumin was found in the urine at this date. Some weeks later she complained of pain in the right iliac fossa. It was noted that the spleen was a little enlarged. She ran a temperature

for six weeks. Although there was no examination of blood for the Widal reaction, this attack was diagnosed as typhoid fever.

On December 11, 1920, she noticed for the first time a slight swelling in the lower jaw. Eating and talking were painful. The swelling gradually increased in size until on Christmas day, whilst eating a piece of bread and butter, she felt her jaw crack. Since then she has felt no further cracking. A loose tooth in the region of the swelling has been removed, and on two occasions the swelling was incised under the impression that it was a dental abscess. Blood only exuded from the incisions.

The foregoing is as complete an account as I have been able to gather of her past history. The interesting points are the diagnosis; the disappearance of the splenic enlargement; the disappearance of the leucocytosis; the attack of fever; the presence of albumin (or was it really albumose?); and the development of the jaw swelling.

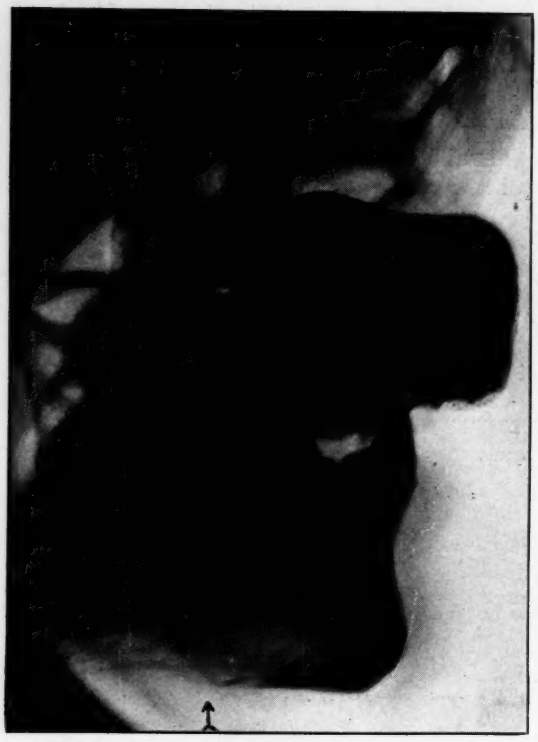

FIG. 150.—Skiagram showing the tumour at the site of fracture.

When I saw her on January 21, 1921, she had an obvious fracture of the jaw just behind the last molar tooth on the right side, with the usual displacement of the posterior fragment inwards and the distal fragment downwards (*Fig.* 150). The fracture was not at all painful. She could talk comfortably and eat remarkably well.

An *x*-ray photograph showed that there was a tumour at the site of the fracture. This tumour was about the size of a walnut. It had absorbed and thinned out the compact bone, which was slightly expanded at the fracture. The mucous membrane was normal over the growth. There was no attempt at union. Otherwise the patient looked fairly well. She was anæmic, and the spleen could easily be felt about one inch below the costal margin. The spleen felt somewhat harder than normal.

No sign of any primary malignant growth was detected in breast, abdomen, uterus, etc.

A blood-count kindly taken by Dr. J. C. Matthews showed red blood-cells 4,500,000, normal morphologically; white cells 12,000 per cmm.

Differential Count.	Per cent.	No. per c.mm.	Normal.
Polymorphs	54·5	6540	6500
Lymphocytes (large and small)	33	3960	2500
Monocytes	12	1440	800
Basophils	5	60	100

In other words, distinct relative and marked absolute lymphocytosis. Slight monocytosis. No myelocytes or metamyelocytes found. Polymorphs show free division of nuclei. Arneth count = right-hand deviation.

Examination of the urine shows the so-called myelopathic albumosuria. Equal parts of salicyl-sulphonic acid and urine give a flocculent protein precipitate which clears on boiling and reappears on cooling. If the urine is acidulated with a drop of weak acetic acid and heated in a water-bath, the protein is thrown down as a white precipitate

at about 60° C. This precipitate almost clears on boiling, and reappears on cooling (Bence-Jones' proteid).

Similarly, nitric acid and hydrochloric acid both precipitate the proteid in the cold, which precipitate is cleared on boiling. In this particular urine, however, the protein is not precipitated by half saturation with ammonium sulphate. The urine also shows the presence of urobilin; an indication of hæmolysis or some tissue deficiency. There is no evidence of sugar, bile pigments or salts, or acetone. (I am indebted to Dr. Coope for the urinary examination.)

This curious protein body in the urine (myelopathic albumosuria of Bradshaw) was first noted in the urine by Bence-Jones in 1847. It is a proteose, and is said to be one of the products of proteolysis on the way to the peptones and polypeptides. It occurs in the urine in cases where there is any absorption of partially digested pus in cases of empyema, pneumonia, etc., and in cases where there is tissue breakdown. It is also said to be diagnostic in myelomata and sarcomata of bone. Dr. T. R. Bradshaw[1] states that "the presence of albumose in the urine is one of the few signs of disease which can strictly be called pathognomonic, admitting, as far as our present knowledge goes, of only one interpretation; and it is usually for many months the only indication of the true nature of the disease from which the patient is suffering, and may for a long time be the sole evidence that he is seriously ill at all. Multiple myelomata, the morbid condition of which it is the sign, goes on to a fatal termination with the certainty of malignant disease, and no measure hitherto attempted appears to have the slightest influence in retarding its progress".

An *x*-ray of the chest revealed no definite shadows of other myelomata in the ribs, the usual situation of these growths.

The interest of this case lies in the diagnosis, and the question whether the two diseases leukæmia and myelopathic albumosuria are related, or independent of each other.

Further points of interest are the extraordinary effect on a leukæmic spleen of a course of *x* rays; and, lastly, the consideration of the prognosis. I think it grave.

ADDITIONAL NOTE—MAY 6, 1921.

This patient died on May 4, 1921.

Unfortunately, no post-mortem was obtainable. The tumour of the jaw increased to about twice its size, but there was no ulceration of the mucous membrane. There were no clinical signs of other tumours. During the last week of her life she suffered from persistent vomiting and diarrhœa. Myelopathic albumosuria was still present a month before she died.

REFERENCE.

[1] T. R. BRADSHAW, *Brit. Med. Jour.*, 1906, Nov. 26.

A CASE OF TUMOUR OF THE CAROTID BODY.

BY GEOFFREY KEYNES, LONDON.

TUMOURS of the carotid body are uncommon, and relatively few cases have been recorded in surgical literature. Keen and Funke[1] collected twenty-nine cases in 1906, and Callison and Mackenty[2] added a further thirty-one to the series in 1914. A perusal of the published accounts of these cases produces a feeling of doubt as to whether they have all been correctly diagnosed, and it is probable that the actual number of cases recorded in which the diagnosis of a tumour arising from the carotid body is clearly correct is considerably less than sixty. It is therefore worth while recording the history and treatment of another case in which the origin of the tumour was beyond doubt.

The patient, a married woman of 31, had noticed a lump in the left side of her neck

for rather over two years, and recently had had transient but severe attacks of aching pain in the left side of her neck and face. In September, 1920, she was admitted to a country hospital, but the growth was regarded as inoperable; she was advised to have treatment at the Radium Institute, but for various reasons this was not carried out. In November, 1920, she was admitted to St. Bartholomew's Hospital, and was then obviously suffering in general health. She was thin, had a poor appetite, and slept badly. She had a solid tumour of a very hard consistency, lying deep to the left sternomastoid muscle, and extending from the angle of the jaw to the level of the cricoid cartilage. It could be moved from side to side, but was fixed in the vertical plane. Arterial pulsation could be felt, but it was clearly transmitted and not expansile. There was no evidence of any infiltration of the sympathetic or recurrent laryngeal nerves, but, as already mentioned, the patient suffered considerable pain, presumably from pressure on sensory branches of the cervical plexus. No other swellings suggesting glandular involvement could be felt. The diagnosis remained in doubt, but an exploratory operation was advised, as the tumour was thought to be of an innocent nature.

On November 26 the tumour was exposed and found to be encapsulated and very hard. It was easily freed from all the neighbouring structures except the carotid vessels, all three being completely surrounded by the tumour, the central point of which seemed to correspond in position to the bifurcation of the common carotid artery. It was evident that the tumour could only be removed after ligature of all these vessels, but unfortunately the risks attending this procedure had not been previously explained to the patient, and it was felt that without this the operation could not justifiably be completed.

FIG. 151.—Tumour of the carotid body. Mesial section. (*Natural size.*)

Among the 60 recorded cases of carotid-body tumour, all three carotid vessels were ligatured in 32 cases; in 4 of these hemiplegia and aphasia followed the operation, and 2 died from cerebral anæmia. That is to say, there were very serious sequelæ in 19 per cent of the cases. In the present instance the patient was comparatively young and presumably had a good collateral circulation, but the fact that the cerebral circulation reaches the brain only through bony foramina, and cannot, therefore, be increased by any expansion of the remaining vessels after ligature of one common carotid artery, seems to be a valid reason for regarding the operation as dangerous at any age. One of the four patients mentioned above, who acquired a hemiplegia, was a child, age seven.

In the present case, accordingly, the wound was closed, to be re-opened a week later, when the tumour was readily removed after ligature of the common carotid, of the internal carotid, and of the individual branches of the external carotid as they emerged from it. It was intended to follow the advice given by Sir George Makins,[3] and to attempt to safeguard the patient's cerebral circulation by first ligaturing the internal jugular vein; but, after freeing the tumour from the adhesions which had formed since the first operation, severe hæmorrhage from its surface occurred; this could not be easily controlled owing to the hardness of the growth, and the main vessels therefore had to be ligatured as rapidly as possible. There did not seem to be any point after this in prolonging the operation by ligaturing the vein.

After the operation the patient suffered from no symptoms of interference with the functions of the left cerebral hemisphere either immediately or subsequently. She made an uneventful recovery, and left hospital on December 21. She has been examined at intervals since that time, and up to the present shows no signs of weakness or of recurrence. She is free from pain, and is able to perform her household duties. A paresis of the left depressor anguli oris due to section of its nerve-supply is gradually disappearing.

PATHOLOGY.—The tumour, after being hardened, weighed 23 grm., and, as can be seen in the accompanying full-size drawing (*Fig.* 151) of a mesial section through it, completely enveloped all three carotid vessels. Microscopic sections (*Figs.* 152, 153)

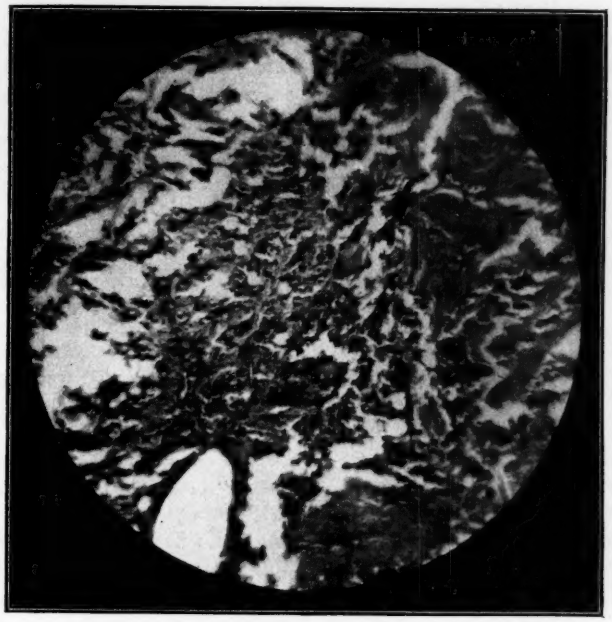

FIG. 152.

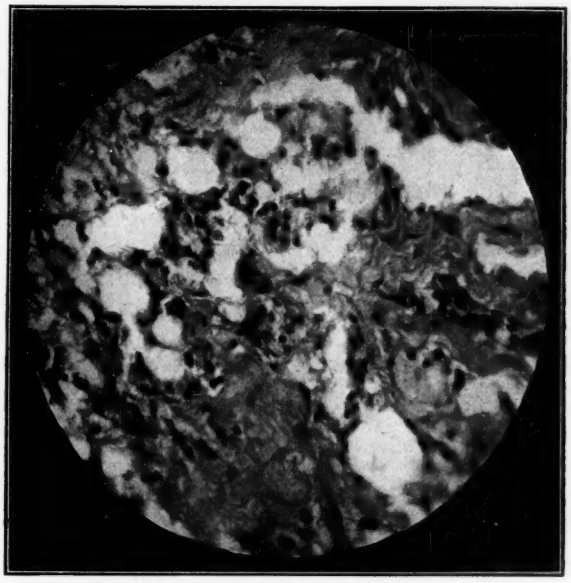

FIG. 153.

show that the growth has not transgressed its capsule, and that it is not very cellular, but contains a large proportion of fibrous connective tissue. It shows a large number of spaces lined by the tumour cells or by endothelium, and some of these contain blood. The cells are of fairly uniform size, and seem to have no characters

suggesting sarcoma. In general the growth is of an innocent endothelial type, and conforms in position and in structure to the accepted description of tumours arising from the carotid body.

In many of the recorded cases the growths were definitely malignant, but there is some evidence to show that they were innocent in their early stages. Recurrence followed in most of the cases in which an attempt was made to dissect the tumour away from the carotid vessels. The history of this case encourages the belief that a carotid-body tumour, if diagnosed early enough, may be successfully treated by complete removal, with ligature of all the carotid vessels.

REFERENCES.

[1] KEEN, W. W., and FUNKE, J., "Tumours of the carotid gland", *Jour. Amer. Med. Assoc.*, 1906, xlvii, 469, 566.

[2] CALLISON, J. G., and MACKENTY, J. E., "Tumours of the carotid body", *Ann. of Surg.*, 1914, lvii, 740.

[3] MAKINS, SIR G. H., *On Gunshot Injuries to the Blood-vessels*, 101. Bristol: Wright & Sons Ltd., 1919

RENAL CALCULUS: HORSE-SHOE KIDNEY: HEMINEPHRECTOMY.

BY L. BATHE RAWLING, LONDON.

THE patient, a man, age 25, states that he was operated on for stone in April, 1920, "several phosphatic stones being removed from the pelvis of the right kidney"—this from notes of the case. During the past few months he has experienced several attacks of renal colic, pain in the right iliac region shooting down the thigh, with nausea and vomiting during the attacks. The skiagram showed several stones in the right renal pelvis.

Cystoscopic examination showed a normal left ureter, whilst the orifice on the right side was obscured by a phosphatic crystal, and the urinary outflow was small and delayed. Abdominal examination showed that the right kidney was enlarged, nodular, oblique in position, and low down in the iliac fossa.

A diagnosis was made of right renal calculi, with nephrectomy as the correct surgical procedure.

The usual lumbar incision was made, the upper pole of the kidney being exposed, freed, and delivered. On attempting to treat the lower pole of the kidney in a similar fashion, it was noted that the obliquity of the kidney was remarkable, and on further endeavour it was found that the kidney substance passed across the vertebral column and was directly continuous, without sign of constriction, with the left kidney.

The right half of this mass was delivered, with considerable difficulty and with some renal laceration. This portion contained, so it was hoped, all the calculi present. The mass was 'crushed' at or near the middle line, anything entering the kidney along its upper border being ligatured as encountered.

The patient made an uninterrupted recovery, the wound being healed within a month of the operation.

REVIEWS AND NOTICES OF BOOKS.

Orthopædic Surgery of Injuries. By Various Authors. Edited by Sir Robert Jones, K.B.E., C.B., F.R.C.S. 2 vols. Royal 8vo. Pp. 1232, illustrated. 1921. London: Henry Frowde, Hodder and Stoughton. £4 4s. net.

The enormous development of orthopædic surgery, which has been one of the results of the recent war, and the fact that no publication has been issued dealing in bulk with the various departments of orthopædic surgery, make the present work a most valuable addition to surgical literature. The subject is dealt with in two volumes, each profusely illustrated, the first containing, amongst other items, a foreword by Director-General T. H. J. Goodwin, the editor's preface, and a chapter on the "Principles and Practice of H. O. Thomas". Sir Robert Jones, in his preface, points out that during the war the number of beds reserved for orthopædic cases rose from 250 to over 30,000, thus showing the importance that this class of work has assumed during recent years. To many who are still dealing with the results of injuries of war, the work will be of the utmost value and aid; and the fact that each subject is dealt with by authors who have had special experience in these subjects, assures the reader of the most modern views upon the surgery of injuries. The chapter on the "Principles and Practice of H. O. Thomas" is full of interest and information, showing as it does that he was perhaps the father of orthopædic surgery in this country, not only as an operating surgeon, but also as one who made his own splints, fitted them to his patients, and followed each individual case to its termination. Thomas had the true orthopædic mind, for, as Sir Robert Jones say in his preface, the orthopædic surgeon is trained to think in terms of function. The orthopædic surgeon, too, has to deal largely with the pre- and post-operative stages of his cases, and it was perhaps in this that Thomas excelled. He died at the early age of 47, leaving behind him, amongst many other results of a life's work, the famous Thomas's knee-splint. It might be said that the adoption of the Thomas's knee-splint for injuries to the lower extremity during the recent war was one of the greatest steps forward in the treatment of the badly wounded man.

With so many chapters written by authors of such experience, it is difficult to mention any one which is particularly outstanding. In *Volume I* the chapters on "Splinting", "Ununited Fractures", "Malunited Fractures", and the "Treatment of Flail and Ankylosed Joints" are especially good. *Volume II* is devoted chiefly to the injuries of the nervous system, and includes an excellent chapter on the "Operative Treatment of War Injuries of the Peripheral Spinal Nerves". There is also a chapter on the "Organization of Curative Workshops", showing clearly the advantages to injured men of using their limbs at the earliest possible moment, not merely by set exercises, but by producing at the same time tangible and useful results.

The whole work is excellently arranged, and each subject fully dealt with from a practical point of view. The fact that Sir Robert Jones—the leading orthopædic surgeon of the day, one who has devoted the whole of even his enormous energy to the subject during the war, and who has brought orthopædic surgery into the prominent position that it holds to-day—has edited this work, is a sufficient guarantee of its excellence. Added to this, the names of many of the authors, the clear and practical way in which most of the chapters are written, and the excellent illustrations, make the work the leading publication of the day upon this subject.

Diseases of the Throat, Nose, and Ear. By Dan McKenzie, M.D., F.R.C.S. Large 8vo. Pp. 646. With 2 coloured plates and 199 figures in the text. 1920. London: William Heinemann. 42s. net.

The author has laid senior students and practitioners under a debt of gratitude in providing them with an excellent exposition of these diseases. No other book we know presents this information so concisely, and with such good illustrations.

Chapter 1 contains many useful observations on note-taking and general semeiology.

Chapter 2 deals with the examination of the buccal cavity, fauces, and pharynx. We are surprised that the author retains the term 'supratonsillar fossa' when it is well recognized that the recess lies within the capsule of the tonsil and is often lined completely with glandular tissue. The illustration (*Fig.* 4) of a peritonsillar abscess is misleading, because the soft palate does not appear to be affected, and yet it is in this particular peritonsillar region that the abscess and swelling are so characteristic.

In the section on diphtheria, more emphasis might be laid on the advisability of giving maximum doses of antitoxin directly the diagnosis has been made. In describing the removal

of enlarged tonsils, the author will find many who do not agree with his methods. Even in hospital practice, where many cases must be enucleated by the guillotine in a limited time, we cannot see any advantage in operating with the patient in the sitting position. With regard to enucleation by dissection, the illustrations leave much to be desired, and it is surely contrary to general experience when he states that " it is a more severe operation than enucleation with the guillotine ; the risks of sepsis are greater ; and the subsequent scarring is more deforming to the fauces and palate ".

It is inaccurate to state (p. 607), that generally the bleeding point " is located on the posterior aspect of the anterior faucial pillar ", because the almost constant source of arterial hæmorrhage is from the tonsillar branch of the descending palatine artery which is situated (and divided in operation) in the outer half of the upper and posterior wall of the bed of the tonsil. On p. 61 we are advised that if the application of the artery forceps has not checked the bleeding, we should " reapply the forceps and either ligature or leave the forceps *in situ* for several hours ". We can only say that bleeding can always be stopped by ligature at the time of operation, and nothing would persuade us to adopt the other alternative.

Again, in reactionary hæmorrhage, we are advised that Watson Williams's clamp should be firmly and accurately applied " and left on for three or four hours ". Has the author ever practised this in a child ? As a last resort, when other methods fail," the external carotid artery should be ligatured ". We should like to know if the author has ever found this necessary, and, if so, whether the operation stopped the bleeding ?

The sections on cancer, syphilis, and tuberculosis of the pharynx are well written, and the value and place of diathermy as a method of treatment insisted on.

Chapters 4 and 5 are devoted to the larynx—the methods of examination and the diseases of that organ. Our present-day knowledge of the subject is concisely stated and well illustrated. Here we must make a criticism, which applies to the whole volume, as to the somewhat careless or unbalanced way in which the names of pioneer workers are often omitted while those of others are mentioned. For example, in the discussion of carcinoma and paralysis of the larynx we find no mention of Butlin, Semon, and Horsley—men who practically established our knowledge on these subjects—while Mr. Stuart Low and Mr. Trotter are given credit for pointing out the value of digital examination in carcinoma of the larynx, whereas it was Dr. J. W. Bond who emphasized this point at least twenty years ago. And why should not Dr. Albert Gray and Mr. Sidney Scott be honoured by mention for their work on otosclerosis and the labyrinth respectively ?

In *Chapter* 6, on the examination and affections of trachea, thyroid body and œsophagus, a clear, concise, and practical account of these subjects is given, but we question how far it is advisable for the laryngologist to extend his domain to the surgery of the neck.

The section dealing with the œsophagus is excellent, but among the symptoms of the so-called 'œsophageal pouch' the author does not mention the characteristic 'gurgling noise' which follows the drinking of fluids ; and we think he could give us a better illustration of a 'pouch' than *Fig.* 55.

To *Chapter* 7, dealing with the examination of the nose and nasopharynx, and general therapy of the nose, we would have given unstinted praise but for the flagrant anatomical errors on p. 217. The infundibulum and frontonasal duct are used as interchangeable terms, whereas they are distinct and often independent anatomical structures ; the former is a gutter bounded on its median aspect by the uncinate process ; the frontonasal duct is a closed canal leading from the frontal sinus into the upper and anterior region of the middle meatus.

We are glad to note that the value of endoscopy receives due notice, and that its advantages as well as its limitations are pointed out by one who speaks from practical experience of the use of this mode of examination.

Chapter 9 is concerned with the accessory sinuses. The author is to be congratulated on his exposition of this important branch of rhinology.

The sections devoted to the maxillary antrum give an excellent account of its diseases and the operative treatment which may be demanded. But many statements are made which are not in accord with general experience, e.g., in discussing exploratory intranasal puncture of the antrum the author states that " bleeding from the cannula is highly suggestive of polypoid degeneration of the lining membrane ". We should have thought it pointed more directly to the possibility of malignant disease. He prefers nasal antrostomy " for practically all cases of antrum suppuration ", whereas many experienced operators have relinquished the intranasal route for the more direct opening in the canine fossa (Caldwell-Luc), because the latter provides a full view of the field of operation. It is not our experience that after the canine-fossa operation convalescence is slow, or that facial neuralgia is a complication to be feared.

Chapters 11 to 14 are devoted to diseases of the ear, and this is the best section in the book. Dr. McKenzie gives an excellent and practical account of the methods of examining the ear which will afford a safe guide to the student and practitioner, and the same may be said concerning what is known with regard to the normal and pathological reactions of the vestibular system. The illustrations of operative procedures are the best we have seen. There is little to criticize adversely in this section. In the operative treatment of exostosis of the meatus we should prefer to approach the obstruction through a post-aural incision rather than by chiselling through the meatus and risking a long course of treatment for the discharge and granulations which operation by that route is liable to involve.

The author is one of the first to emphasize, in print, the importance of detecting and treating serous catarrh of the tympanum before it has had time to set up permanent changes in the middle ear which may lead to incurable deafness, tinnitus, etc. But we think the observer will rarely see the fluid level so clearly as is depicted on p. 464.

Dr. McKenzie advises leeches over the mastoid in the earlier stages of acute inflammation in the middle ear, but he does not point out that the œdema which results from their bites may suggest inflammation in the mastoid cells. We wish that he had extolled the value of suction with the Siegel's speculum after paracentesis of the membrane, because by this means it is often possible to remove a quantity of pus from the tympanum and its adnexa.

Unstinted praise may be given to the description of the symptoms, diagnosis, and operations in relation to the meningeal and cerebral complications of acute and chronic inflammation of the tympanum and its adnexa.

Chapter 14 on nerve deafness and labyrinth disease is full of useful information; it should be studied by all who are interested in diseases of the ear.

In *Chapter* 16 we have a useful account of the commoner diseases of the mouth, salivary glands, and the palate, which often come under the notice of the ear and throat specialist during routine examination. Even if the treatment of some of these conditions is outside his province, it is nevertheless essential, and often to the benefit of the patient, that the significance and bearing of pathological conditions of the mouth, tongue, and salivary glands should be recognized.

In conclusion, Dr. Dan McKenzie is to be heartily congratulated on having successfully accomplished a difficult and almost unique task, in that he has given us in one well-illustrated volume an excellent account of the diseases of the throat, nose, and ear. Furthermore, this has been done in easy and fluent style, and yet with an atmosphere of conviction which can only be derived from personal experience.

The Catarrhal and Suppurative Diseases of the Accessory Sinuses of the Nose. By Ross Hall Skillern, M.D., New York. Third edition. Large 8vo. Pp. 418 + xvii, with 300 illustrations. 1920. Philadelphia and London: J. B. Lippincott Co. 30s. net.

In this third edition of his well-known work, the author has presented the profession with the most complete work on the subject in the English language.

The book is not a mere compilation of what is known of the anatomy, physiology, and pathology of the nasal accessory cavities, but the reader profits throughout by the ripe experience and enthusiasm of the author, which is always held in check by well-balanced judgement. The type is clear, one is never in doubt as to the author's meaning, and the 300 illustrations could scarcely be improved upon.

Part I is devoted to "General Considerations". It embodies a careful, accurate, and practical description of the anatomy, physiology, and development of the nasal cavities and their accessory sinuses. But why does Dr. Skillern so frequently use the word 're-absorption' of bone in describing the development of the sinuses? Surely *absorption* is fully significant and more accurate.

The section on the bacteriology of the sinuses is excellent. He points out that while the primary inflammation of a sinus may be caused by a certain organism, e.g., the influenza bacillus, yet the continuance of that condition may be due to a secondary infection by other organisms which find the ground suitably prepared for them, while the primary agent of infection may long since have disappeared. Furthermore, the type or types of organisms may often change during the course of the disease.

In discussing the symptoms of sinus inflammation, Dr. Skillern rightly lays stress on the fact that a constant or frequent headache should always lead to a careful examination of the nasal cavities and their sinuses, and he is impressed with the frequency with which pressure on the septum from mucous-membrane hypertrophies causes headache.

On the other hand, we do not share his experience when he says he "has never observed such a case" as chronic purulent inflammation of the sinuses without any headache; while we are fully in accord with him when he states that all cases of 'tic' are not caused by sphenoidal-sinus inflammation as maintained by some rhinologists.

His views as to the unreliability of transillumination in the diagnosis of sinus inflammation will be upheld by all careful workers. He rightly extols the value of radiography, and points out its reliability in diseases of the ethmoid sinuses, in establishing the presence or absence of certain types of dental disease, and in revealing the presence of new growths in the sinuses.

The section on the "Complications of Sinus Inflammation" is excellent, and particularly so with regard to orbital affections.

We are glad to see the writer draws attention to sinus disease in children, an aspect of the subject which has been so constantly overlooked by many other authors.

Part II is devoted to the anatomy and diseases of the maxillary antrum. These are given in full detail, and the illustrations are excellent.

We do not agree that disease of the antrum of dental origin is always "chronic from its inception", because an acute antral suppuration is often the culminating point of an acute dental inflammation. It is regrettable that the author lends the weight of his authority to 'air injection' after needle puncture in diagnosis and treatment, because some twelve deaths have

been recorded as a result of air embolism following the employment of this method. The reviewer had one alarming case of aphasia and right arm and leg hemiplegia lasting for an hour, and since then has always irrigated with a warm normal saline solution.

Nor do we see the advisability of packing the antrum with gauze after any intranasal or extranasal operation. The object of these procedures is to provide for free and permanent drainage; to insert packing means that before the patient is off the table the gauze is saturated with blood and septic secretions, with the result that post-operative swelling and œdema of the cheek frequently results, to say nothing of the pain which is caused when the packing is removed.

Excellent descriptions of the various radical operations are given, and full directions as to inducing local anæsthesia in preference to general narcosis. It is unfortunate that the former method cannot annul mental anticipation and anxiety, and on this account we are of opinion that local anæsthesia for major operations on the accessory sinuses should be reserved for very exceptional circumstances if the services of an expert in general anæsthesia can be secured.

Part III is devoted to the frontal sinus, and is of the same high standard as that which characterizes *Part II*; but once more we take exception to the author's advice that after inserting the cannula in the sinus "the syringe is filled with air and the latter forcibly inflated into the sinus cavity". We agree with him that transillumination of the frontal sinus is of little value compared with radiography in establishing the presence of inflammatory changes.

The pros and cons of the intranasal method of operating on the frontal sinus are clearly defined, and the young rhinologist will do well to bear in mind the author's warning: "The various intranasal operations described above require a skill and proficiency that are only obtainable after the sacrifice of a considerable amount of time and trouble by numerous experimental operations on the cadaver".

The various intranasal operations, as well as those performed outside, are profusely illustrated.

Parts IV and *V* are devoted to the ethmoidal and sphenoidal sinuses respectively, and it will suffice to say that the subject matter and the illustrations deserve the same praise as that which has been bestowed on *Parts I* and *II*.

To Dr. Skillern's book the expert will often turn when in need of information concerning details of pathology, treatment, etc., and also because of the large number of useful references to the work of other rhinologists. The younger worker in this department of surgery will find in the volume a mine of information and a sure and safe guide in his practice.

Text-book of Tracheobronchoscopy (Technical and Practical). By Dr. M. Mann (Dresden-Friedrichstadt). Translated by A. R. Moodie, F.R.C.S. (Edin.). 4to. Pp. 292, with 50 illustrations in the text and 15 plates (10 coloured). 1920. London: John Bale, Sons & Danielsson Ltd. 31s. 6d. net.

The author states that his aim is to show that tracheobronchoscopy is no longer merely a technique by which one is able to remove foreign bodies from the air-passages, but is a method of investigation in the study of numerous diseases of the thorax. In this we think he has succeeded.

Part I deals with the technique of tracheobronchoscopy. In this are included anatomy, history, instruments, and other details concerning the direct method of endoscopy.

He briefly reviews the various modifications introduced by European workers as well as those of Chevalier Jackson and Ingals in the United States; but one infers that he has not availed himself of the advantages of distal illumination as opposed to the proximal source of illumination used by the Killian school. He makes no mention of work done in Great Britain and Ireland in tracheobronchoscopy—a serious omission in a scientific treatise.

In *Chapter* 4, on the preparations for tracheobronchoscopy, the author rightly urges the need for a careful general examination of the patient before endoscopy is practised, and this should include radiography. He contends that anæsthesia is indicated before the introduction of the bronchoscope, and in this opinion we are in accord with him. A 20 per cent solution of cocaine is advised, and it is applied with a hair brush. A 1 per cent solution of the harmless double salt of quinine and urea, with the addition of adrenalin solution (1–10), is extolled as a rapid and efficient anæsthetic for the tracheal and bronchial mucous membrane.

He says that the question of local or general anæsthesia varies according to the experience and skill of the observer, but we should be inclined to add that the choice will depend largely on the nature of the case and the temperament of the patient.

Dr. Mann states that "chloroform is the only anæsthetic that can be recommended, as ether irritates the bronchi and stimulates the secretion". We wonder if he has ever tried ether preceded by a hypodermic injection of $\frac{1}{100}$ gr. of atropine administered thirty to forty minutes before the administration of the general anæsthetic? We believe he would soon be converted to the advantage of obtaining deep narcosis by such a stimulant as ether and then continuing the anæsthesia with chloroform for the actual period of operation.

Pp. 47–53 are devoted to the methods of introducing the bronchoscope in the sitting or recumbent positions.

With regard to tracheobronchoscopy in children, the author omits an important warning, viz., to use the smallest tubes consistent with obtaining a satisfactory result. The inexperienced operator is inclined to use the largest tube possible, and this frequently leads to post-operative œdema of the subglottic region, with grave risk of dangerous dyspnœa.

Part II is concerned with the practice of tracheobronchoscopy. *Chapter* 1 cites the salient features of a number of cases in which different types of foreign bodies have been removed by endoscopists in various parts of the world. A useful summary of the practical conclusions to be drawn from the cases is given.

Chapter 2 is devoted to tracheobronchoscopy in diseases of the bronchial system. This is perhaps the most useful portion of the book, in that it shows that endoscopy is not, nor should be, limited to dealing with foreign bodies, because it has proved to be of immense value in the diagnosis and treatment of pathological conditions of the lower air-passages. Epraim's results in the treatment of chronic bronchitis and asthma are worthy of serious consideration and emulation. We think the author should have emphasized the fact that unilateral bronchiectasis in children is more often than not due to a foreign body lodged in a bronchus or in one of the bronchial tubes.

An excellent series of coloured plates which illustrate normal appearances and pathological conditions concludes the volume.

The value of a future edition would be enhanced (1) if the literature of the subject were brought more up to date, so that endoscopists could depend on the volume as a reliable source of reference, and (2) if the author could see his way to illustrate some of the excellent instruments invented, and refer to the valuable communications which have from time to time been recorded by English-speaking workers in this special branch of laryngoscopy.

Six Papers by Lord Lister, with a short biography and explanatory notes. By SIR RICKMAN GODLEE, Bart., K.C.V.O., M.S. Medical Classics Series. Cr. 8vo. Pp. 194 + vii. 1921. London: John Bale, Sons & Danielsson Ltd. 10s. net.

THIS little volume appears as the first of a series of Classics of Medicine, the aim of which is to place in the hands of the reader some of the most epoch-making contributions to medical science. The general editor of the series is Dr. Charles Singer, Lecturer in the History of Medicine, University College, London. The name of the author is a sufficient guarantee of the excellence of this first volume of the series. Lister's place in history is put before the reader in a short account which explains the condition in which Lister found surgery and that in which he left it. It enables the student to understand the relation of Lister's work with that of Pasteur, for whom Lister entertained the most profound admiration.

Just so much reference is made to Lister's private life as is necessary to complete the whole and to apportion the work to the periods spent in London, Edinburgh, and Glasgow respectively. The first paper brought before us is that "On the Early Stages of Inflammation", read before the Royal Society on June 18, 1857, when Lister was just over thirty years old, and of this the section dealing with the effects of irritants upon the tissues is printed almost in full.

Then follow a paper on 'Anæsthetics', one of two contributions to *Holmes's System of Surgery* in 1861; and a paper on "A New Method of Treating Compound Fractures, Abscesses, etc.", published in *The Lancet* in 1867. The next place is allotted to an account of two demonstrations of antiseptic surgery given to the British Medical Association in 1875, when Lister was Professor of Clinical Surgery at Edinburgh. The two concluding papers take the form of addresses: one on 'Fermentation', delivered in King's College, London, in 1877, and the other on "The Present Position of Antiseptic Surgery", delivered before the International Medical Congress, Berlin, in 1890. Each paper is prefaced by valuable explanatory notes by the author, and Sir Rickman Godlee is deserving of the gratitude of the profession for having supplied this ready opportunity of studying at first hand the original records of Lister's monumental work.

Feebleness of Growth and Congenital Dwarfism, with special reference to Dysostosis Cleidocranialis. By DR. MURK JANSEN, O.B.E., Lecturer on Orthopædic Surgery, University of Leiden, Holland. Large 8vo. Pp. 82, with 40 illustrations. 1921. London: Oxford Medical Publications. 12s. 6d. net.

DR. MURK JANSEN has many claims on the attention of British surgeons. He speaks and writes our language fluently; he is a recognized authority on orthopædic surgery; during the war our wounded interned in Holland had the benefit of his skill.

In 1912 he published in English a monograph on achondroplasia, with many excellent illustrations. He was then convinced that this remarkable disturbance of growth could be best explained by supposing the amnion to have exerted an injurious pressure on the embryo at an early stage of its existence. In the present work we are glad to note that he concentrates his attention on the very marked alterations which are to be seen in the epiphyseal lines of all cases of achondroplasia. In all conditions where there is dwarfism or enfeebled growth, definite departures from the normal are to be found at these zones of bone-growth. He recognizes that the sexual glands can and do exert an influence on the growing tissues of muscles and bones; but dwarfism and enfeebled growth he regards as being due not to the lack of any hormone or product of internal secretion, but to the presence of some noxious substance in the circulating blood. His position may be made clear by the following quotation (p. 20):—

"The same nocivity, an intestinal catarrh, which will cause death, or pædatrophy or athrepsy in the first year of life, may provoke diaphyseal or epiphyseal rachitis in the following years, muscular weakness—attended by even excess of body-height—during adolescence. Hence the fact

that the first year of life is characterized by high mortality and by pædatrophy or athrepsy, whilst the following years successively show a tendency toward diaphyseal rachitis, epiphyseal rachitis, and muscular weakness with excess of height, is explained by the diminishing rapidity of growth of the individual, i.e., in view of the law of the vulnerability of fast-growing cell-groups."

We fear this explanation takes us no further than informing us that feebleness of growth and ill-health are often associated.

The second part of Dr. Jansen's book is devoted to a restatement of his theory of amniotic pressure as a cause of dwarfism. Amongst the ill-effects of amniotic pressure he includes not only craniocleidodysostosis and congenital dislocation of the hip, but also anencephalic fœtuses. Now it has been demonstrated over and over again that the condition of anencephaly can be produced by experimental means—hatching eggs at abnormal temperatures, or by exposing embryos to injurious salts or substances. No one has yet shown that abnormal amniotic pressures could produce the results ascribed to them by Dr. Jansen.

We commend some of the excellent illustrations which the author has reproduced in this work, and congratulate him on the tenacity he has shown, and is showing, in following up the causes of defective growth.

History and Bibliography of Anatomic Illustration in its Relation to Anatomic Science and the Graphic Arts. By LUDWIG CHOULANT. Translated and edited with notes and a biography by MORTIMER FRANK, B.S., M.D. Large 8vo. Pp. xxvii + 435, with numerous illustrations. 1920. Chicago: The University of Chicago Press. $10 net.

IN 1852 Dr. Ludwig Choulant, of Dresden, published his classical work on the *Geschichte und Bibliographie der anatomischen Abbildung*. The book has long been unattainable, and it was a meritorious action, therefore, on the part of Dr. Mortimer Frank to translate and issue what is practically a new edition. Dr. Frank died in April, 1919, at the early age of 44, and the publication of the book has been entrusted to Dr. Fielding H. Garrison and Dr. Edward C. Streeter, who have added a short biography of the translator and have appended two valuable articles, the one dealing with sculpture and painting as modes of anatomical illustration, the other on anatomical illustration during the last sixty years.

Choulant rather arbitrarily divided the history of modern anatomical illustration into six periods, the first being before the advent in 1521 of Berengarius da Carpi, the friend of Benvenuto Cellini, the last beginning at 1778, when Antonio Scarpa and von Soemmerring were directing attention to the viscera and the nervous system. Choulant gives a short account of each writer in each of these periods, with a criticism of their artistic work, in many cases with a copy of one of their illustrations and a bibliography of the chief editions of their works. The general conclusion is that the older anatomists devoted themselves almost exclusively to the accurate delineation of the muscles, skeleton, and superficial veins and nerves, so that the illustrations were of greater use to the artist than to the surgeon. Indeed, surgeons had very little use for expensive and well-illustrated anatomies, which they were usually too poor to buy or too ignorant to desire. Such anatomy as they knew was learnt by compulsory attendance at the public dissections required of them by the particular Company of Barber Surgeons of which they were members.

There is still room for improvement in the bibliographical portion of the work—though the translator and the editors have enlarged it to some extent, and have acknowledged and utilized the work of Professor Sudhoff. On page 104 "Count" Arundel should be The Earl of Arundel, the friend of Dr. William Harvey, and on page 176 the Greek word 'skeleton' should be in the genitive and not in the nominative as it is printed. On page 177 Vesalius' little play on the Hebrew words has been slurred over with an "&c". They might just as well have been transliterated. The book is provided with a good index, which adds greatly to its value.

Des Andreas Vesalius sechs anatomische Tafeln vom Jahre 1538 in Lichtdruck. (The six anatomical plates published by Andrew Vesalius in 1538, reproduced by photo-lithography). Edited by MORIZ HOLL and KARL SUDHOFF. 1920. Leipzig: Johann Ambrosius Barth.

THESE celebrated plates are issued in a somewhat reduced form as a memorial of the quatercentenary of the birth of Andrew Vesalius, the father of modern anatomy. They are the first-fruits of the work of Vesalius, and were engraved at Venice by Johannes Stephanus von Calcar, a pupil of Titian. Being 'fly-leaves'—that is to say, being issued separately and unbound for the use of artists and others who were studying anatomy—they became so scarce that it was doubtful whether any copies existed. Two sets of plates, however, were found; and in 1874 Sir William Sterling Maxwell reproduced his plates in facsimile at his own expense, the issue being limited to thirty copies. The present volume renders them accessible to the general student of anatomy. In addition to the six plates, Professor Sudhoff has added a short historical introduction, and Professor Holl, of Graz, has written a description of the drawings. There is also a reproduction of the *Nervorum delineatio* which was designed by Vesalius and pirated by Macrolios. The plates consist of the skeleton, and one of the venous and one of the arterial system. Their value lies in the fact that they show the anatomical knowledge possessed by Vesalius in 1538 as compared with that displayed only five years later, when he issued the first edition of his great work on anatomy *De corporis humani fabrica*. In this short interval he had come under the influence of Leonardo da Vinci and had learnt to observe.